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Memorandum on Tea Experiments Conducted by the Department of Agriculture, F.M.S. & S.S.

B. Bunting.

This memorandum was prepared for a special meeting of the Advisory Committee which was held at the Offices of the Department of Agriculture on the 28th November, 1928 to consider the possibilities of tea cultivation in Malaya and whether it was necessary for the Department to carry out any further experiments with tea other than those now being undertaken.

Several experienced tea planters, in addition to members of the Advisory Committee, were invited to attend this meeting and give the committee the benefit of their advice as to the possibility of growing tea both on the plains and the highlands in this country.

While the majority of the committee was in favour of the general development of tea planting in the highlands it was decided that the potentialities of the lowlands should be thoroughly investigated and that the experimental work already in progress at the Experimental Plantation, Serdang be extended where possible.

Introductory.

In January, 1914 the Director of Agriculture circularised several well-known planters, experienced in tea planting, with a view to obtaining their services for the purpose of inspecting and reporting on the suitability for tea cultivation of land at Lubok Tamang (3,500 feet above sea level)

in what is now known as Cameron's Highlands. The proposal had, however, eventually to be dropped as it was not found possible to arrange suitable terms with the only planter willing to undertake the journey.

During March, 1914 Mr. M. Barrowcliff, Assistant Agricultural Chemist, paid a visit to this area and explored a portion of the Bertam Valley from the Sungei Renglet to the foot of Gunong Berembun. An account of his visit was submitted to the Director of Agriculture on the 20th April, 1914 under the title "Report on a visit to Cameron's Plateau". Mr. Barrowcliff took a number of soil samples from the land explored and the conclusions he arrived at after discussing and comparing his analyses with some of those of the best tea soils in North-East India were, that the Lubok Tamang samples conformed in every respect to the requirements of a good tea soil and that there was no reason apparent why tea of high quality should not be produced in this locality. Further analyses of the soil samples from Lubok Tamang reported on by Mr. V. R. Greenstreet, Assistant Agricultural Chemist, and published on pages 281-282 of the Malayan Agricultural Journal, Vol. X, September, 1922, supported the opinion expressed by Mr. Barrowcliff.

Experiments at Gunong Angsi.

At the end of 1914 a small quantity of dark-leaf Manipuri Assam tea seed was obtained through Mr. Thos. More, Manager of Sungei Buloh Estate, Kuala Selangor for trial at the Experimental Plantation, Gunong Angsi. These seeds were sown in nursery beds at the Experimental Plantation, Kuala Lumpur and the seedlings were transferred to Gunong Angsi at the end of 1915 for planting up one acre of virgin land at an elevation of 2,100 feet.

In 1915 a further small quantity of light-leaf indigenous Assam seed, received from the same source, was planted in nursery beds at Gunong Angsi at an elevation of 1,200 feet. The germination of the seed was fairly good and sufficient seedlings were raised for planting up one acre of this variety on a plot adjoining the Manipuri variety at an elevation of 2,100 feet. The area selected was fairly steep and terraces were constructed at about 6 feet intervals. The seedlings were planted on the contour at distances of 4 feet apart during October, 1916.

The growth in each case was quite good and the bushes were pruned back to within about 9 inches of the ground when about one year old. Both lots of plants eventually developed into fair-sized bushes, but no reliable records of the yield of fresh leaf are available.

As this Experimental Plantation was abandoned in 1922 the plots very soon became neglected and the majority of the plants died out.

Mr. T. D. Marsh, Assistant Agriculturist, visited Gunong Angsi on the 7th November, 1928 to inspect this area and found that owing to the growth of blukar and damage by fire the majority of the plants had died out and only about 200 overgrown bushes remained.

A few of the bushes were seeding and it was possible to collect a small quantity of seed, but in view of the small number of plants which exist in this area it is questionable whether it is worth while clearing them up from the point of view of seed production.

Experiments at the Experimental Plantation, Serdang.

During 1924 an area of about 5 acres of virgin land adjoining the North-West corner of Block 3 was cleared with the object of planting up one-acre plots of four varieties of Assam tea and a one-acre plot of the local Chinese variety. This land is undulating, protected on the North, South and West by secondary jungle, and the soil consists of a friable laterite loam.

In December, 1924 a small consignment consisting of ½ maund seed of the Dangri variety of tea was received from the Dangri and Dhonjan Tea Seed Co. of Dibrugarh, Assam, while a second consignment, consisting of ½ a maund seed of each of the Betjan, Dhonjan and Rajghur varieties, was received from the same source in January, 1925.

The following is a brief description of the four varieties selected for trial at Serdang:—

(1) *Dangri.*—A pure Manipuri jat, derived from the original Manipuri stock. It has a dark leaf, is very hardy and bushes quickly.

(2) *Dhonjan.*—A pure Assam variety, derived from indigenous Assam stock. It has a large dark green leaf, flushes freely and is comparatively hardy.

(3) *Betjan.*—A pure Assam jat, derived from indigenous Assam stock, having a large leaf of medium colour, but not so large as some of the light-leaved varieties. It is a heavy yielder and noted for its large "fat tips".

(4) *Rajghur.*—A cross between a pure Assam and a pure Manipuri plant. It is a high yielder and very hardy.

The Dangri seed, comprising the first consignment, was sown on the 16th December, 1924 and the Dhonjan, Betjan and Rajghur seed, comprising the second consignment, was sown on the 18th January, 1925. Both lots of seed were germinated in boxes and the newly germinated seedlings planted straight out in the field.

The results of germination were as follows:—

Jat.	Quantity of seed.		No. of seeds received.	No. of seedlings established.	Percentage germination.
Dangri	½ maund	...	7,256	3,700	51
Dhonjan	,,	...	9,447	6,896	73
Betjan	,,	...	8,168	2,858	35
Rajghur	,,	...	8,325	5,078	61

The low percentage of the seedlings established was due to a large proportion of cracked seeds having germinated in transit.

A commencement was made to lift the seedlings of the Dangri variety from the boxes and transplant them in the field in January, 1925, while the other varieties, Dhonjan, Betjan, and Rajghur were transferred to the field in February and March, 1925.

The distance of planting in the field was 4 feet x 4 feet, giving 2,722 plants per acre.

Chinese Variety.—A small parcel containing 5½ lbs. of seed of a Chinese variety of tea was obtained from the 10th mile Cheras, Selangor in December, 1925. This seed was sown in boxes on the 10th December, 1925. From 1,958

seeds comprising this parcel 945 seedlings were raised and these were planted out in the field on the 6th November, 1926 at distances of 4 ft. x 4 ft. square.

The following records show the results of germination tests with seed of the local Chinese variety of tea:—

Nature of Seed.		Percentage germination.	Period of germination.
Ripe seed "floaters"	...	22	52 days.
Ripe seed "sinkers"	...	64	43 ,,
Unripe seed "floaters"	...	2	47 ,,
Unripe seed "sinkers"	...	42	48 ,,

Soil Conservation.—In January, 1925 *Tephrosia candida* was planted between alternate tea plants in alternate rows in order to produce low shade. The subsequent treatment of the green manure plants consisted of periodical pruning of the lower branches so as to form "standards" which would provide auxilliary shade for the young tea bushes.

During October, 1925 the whole area was silt-pitted, the pits being dug 4 ft. x 1 ft. x 1 ft. between the *Tephrosia candida* plants. It was observed later that a certain amount of soil erosion was taking place and extra pits were dug wherever possible.

Shade.—In November, 1925 *Gliricidia maculata* was planted on the triangular system in rows 56 feet apart and 40 feet apart in the rows, so as to provide top shade.

Supplying.—During November, 1925 the Dangri plot was completely supplied, but there were insufficient plants in the nurseries to supply all the vacancies in the plots containing the other varieties. Further, it was found impossible to obtain an extra supply of seed from Assam to supply the vacancies occurring in these plots.

Pruning.—The plants were all pruned back to within about 9 inches from the ground in October, 1926. The bushes were again pruned back in October, 1927 to within 3 inches of the previous cut and in December, 1927 all the small shoots were "hard nipped" in an endeavour to make the bushes spread laterally and thus provide a large number of shoots from which leaf might be plucked later.

Prior to the pruning in November, 1927 a small quantity of leaf was plucked and an attempt was made to cure it, but the absence of any drying apparatus made it difficult to obtain a sample of tea fit for consumption.

At the end of 1927 the *Tephrosia candida* was beginning to die out, consequently it was dug up and the prunings turned into the soil as a green manure.

Plucking.—The tea plants were again heavily pruned during August, 1928. This operation was carefully carried out so as to encourage the spreading of the branches and thus give a wide low bush which would facilitate the plucking of the leaf. During the second half of September and the beginning of October the bushes were topped to a low level in order to encourage flushing. On the 12th October, 1928 a regular seven-day round of plucking was commenced and the yields of fresh leaf have been recorded since this date. The growth of these bushes in February, 1929 is shown in Plate I.

Manufacture.—The method of manufacture at present employed is somewhat primitive. A portable withering tat has been constructed and is now in use, but the results so far obtained are not altogether satisfactory. There are no facilities at present for artificial withering, consequently it is almost impossible to obtain good tea during the wet season since practically no drying of the leaf takes place. The air being saturated with moisture the leaf structures, instead of withering naturally, begin to decompose.

The rolling is being carried out by hand, which is not very satisfactory. A small hand-power roller has, however, been ordered from Colombo, while a small drying kiln is now under construction, so that considerable improvement in the manufacture may shortly be expected.

Shade Trees and Windbreaks.—During November, 1928 seedlings of *Grevillea robusta* were planted at distances of 40 ft. apart in the rows between the plots, so as to give auxilliary shade and act as a windbreak.

Cover Plants.—Experiments are being conducted with the planting of cover plants so that observations can be made on the growth of the tea under cover plants compared with growth on clean-weeded areas. The cover plants under trial at present include *Centrosema pubescens, Dolichos Hosei* and *Indigofera endecaphylla.*

Diseases and Pests.—Although isolated cases of a root disease, causing a rot, have occurred from time to time no serious diseases or pests have so far been recorded on these experimental plots.

Vegetative Propagation.—Experiments are now being conducted at Serdang with the object of multiplying stocks of tea by means of vegetative reproduction and the following methods are being adopted for this purpose:—

(1) The striking of cuttings from prunings.
(2) "Gootee" layering of the outside lower branches of the tea bushes.

The experiments have already been attended with a certain amount of success and may prove of considerable value in connection with the propagation of high yielding types.

Experiments at the Experimental Plantation, Cameron's Highlands.

In January, 1925 a small consignment of seed of three varieties of tea was received from Assam for planting at the Experimental Plantation, Serdang and 200 seeds of each variety were taken up to Cameron's Highlands by Mr. J. N. Milsum, Assistant Agriculturist, when on a visit of inspection towards the end of that month. These seeds were sown in prepared nursery beds on low-lying land at the Experimental Plantation, Tanah Rata. Germination was good and in January, 1926, 437 seedlings raised from this stock of seed were planted out on a small plot of land, facing the office and store, in Block D. 1. The elevation of these plots is approximately 4,650 feet above sea level and the distance of planting is 4 ft. x 4 ft., which gives 2,722 plants per acre.

The following particulars show the varieties and number of seedlings comprising these plots:—

	Jat.	No. of Plants.
Plot A.	Betjan	180
Plot B.	Dhonjan	140
Plot C.	Rajghur	117

The following measurements were taken of the four largest plants in January, 1927, which was exactly one year after planting out in the field:—

Bush No. 1	4 ft. 10 ins. high	2 ft. 6 ins. spread.
,, 2	4 ft. 10 ins. ,,	3 ft. 0 ins. ,,
,, 3	4 ft. 4 ins. ,,	2 ft. 3 ins. ,,
,, 4	3 ft. 11 ins. ,,	2 ft. 8 ins. ,,

The pruning of the above plots prior to plucking was undertaken in April, 1927 and actual plucking operations commenced on the 24th July, 1927. The bushes were cropped regularly from this date at intervals of 9 to 10 days. During the twelve months ending the 23rd July, 1928 the total weight of dry tea harvested amounted to 78 lbs. 6 ozs. Taking the area of these plots as 1/6 of an acre this is equivalent to a yield of 470 lbs. of made tea per acre during the first year of cropping. The growth of these bushes in October, 1928 is shown in Plate II.

Although it is somewhat dangerous to place much reliance on calculated yields the figures quoted above are sufficiently high to allow of a big margin of error in estimating the probable yields which may reasonably be expected on the highlands.

In January, 1927 a consignment of a ¼ maund of seed of the Muttapong Manipuri variety was received from Assam, through Messrs E. S. Stewart & Co., Calcutta, and contained 4,756 seeds, which were planted in baskets on the 15th January. This is a dark leaf Manipuri variety. The seeds were planted up in baskets and germination commenced on the 20th February.

At the end of June, 1927 only 1,215 seedlings had been established in baskets, which was a very poor rate of germination. Owing to the bamboo baskets showing signs of falling away from the plants, with a consequent drying out of the soil, these seedlings were planted out in July, 1927 on terraced land, in Block E. 1, with satisfactory results.

In March, 1927 another consignment of seed was received from Assam, through Messrs E. S. Stewart & Co., Calcutta, and comprised the following varieties:—

(1) *Charali Manipuri.*—A pure Manipuri plant having a dark leaf.

Tea bushes, four years old, at the Experimental Station, Cameron's Highlands.

(2) *Charali Assam.*—A pure Assam variety having broad leaves of medium colour.

(3) *Amulguri.*—Pure indigenous dark leaf Assam plant.

(4) *Dutea Manipuri.*—A pure Manipuri variety.

The above seeds were sown direct in nursery beds in March, 1927 and the following results of germination were obtained:—

Jat.		Quantity of seed received.	No. of seedlings established.
Charali Manipuri	...	¼ maund	2,620
Charali Assam	...	,,	2,608
Amulguri	...	,,	2,780
Dutea Manipuri	...	,,	1,957

It should be stated here that as a large number of seeds were broken and others had already commenced to germinate it was impossible to record the number of seeds received in this consignment.

All these seedlings were planted out in Blocks D. 1—E. 1 on Spur No. 3 during the interval between the middle of November and end of December, 1927. The first pruning operation took place on these plots during August, 1928.

The following are particulars of additional tea seed received at the end of 1927 and beginning of 1928, which comprises the present stock of 60,000 seedlings in the nurseries, (see Plate III).

In December, 1927 an additional consignment consisting of 1 maund of Charali Assam seed was received from Assam, through Messrs E. S. Stewart & Co., Calcutta. The results of germination were as follows:—

Jat.	Quantity of seed.	No. of seeds received.	No. of seedlings established.	Percentage germination.
Charali Assam	1 maund	14,302	13,242	93

These seedlings are still in the nursery beds, but an area of land is now being prepared on the western slope of Spur No. 3 for planting up a one acre plot of this variety. A duplicate plot of the same variety is to be planted up on the opposite slope of this spur later on.

In January, 1928 a still further consignment consisting of 4 maunds of seed was received from Assam, through the Planters' Stores & Agency Co., Ltd., Calcutta. The results of germination were as follows:—

Jat.	Quantity of seed.	No. of seeds received.	No. of seedlings established.	Percentage germination.
Betjan	1 maund	13,000	12,254	94
Dhonjan	,,	11,024	10,716	97
Rajghur	,,	14,000	13,610	97
Dangri	,,	10,340	8,394	81

As stated above, these seedlings are still in the nursery beds and will soon be ready for planting out in the field. An area of about 4 acres on the western slope of Spur No. 3 in Block E. 1 has been clean cleared and holed ready for planting up one acre plots of each of the above varieties, while instructions have been given to prepare a similar area on the eastern slope of this spur for planting up duplicate plots as early as possible.

Diseases and Pests.—The plants have not yet suffered from any serious diseases or pests, but one or two cases of root disease have been observed, specimens of which have been submitted to the Mycologist for investigation.

GENERAL.

Since writing the above memorandum 5 maunds (400 lbs.) of tea seed have been received from Assam for planting at the Experimental Plantation, Serdang, while a further 5 maunds of low-country tea seed have been ordered from Ceylon for the same purpose and delivery is expected within the next few weeks.

Allowing for 1 maund (80 lbs.) of seed being required to plant up 3 acres of land the above supply of tea seed should provide sufficient seedlings to plant up a further area of about 30 acres at Serdang.

The following tea machinery has since been received at the Experimental Plantation, Serdang:—

1 "Little Giant" Tea Roller (capacity 60 lbs. withered leaf per charge).

1 Roll Breaker, 9 feet long.

1 Tea Cutter, fitted with ⅜ cells.

PLATE I

Manipuri Tea, four years old, at the Experimental Plantation, Serdang.

Tea nurseries at the Experimental Plantation, Cameron's Highlands.

In addition to the above, a set of hand sieves and a supply of jute hessian have been received, which will be sufficient for carrying out preliminary experiments in the manufacture of tea from the 5 one-acre plots now in bearing at Serdang. As soon as this machinery has been installed it is intended to prepare representative samples of lowland tea and obtain, with the assistance of the Malay States Information Agency, a report on its quality and commercial value.

A sample of hand made tea produced from 4 year-old plants growing at the Experimental Plantation, Serdang was recently submitted to Messrs. Whittall & Co., Colombo, who made the following report and valuation on the sample in question:—

Liquor.—Has good colour, but tastes somewhat burnt.

Leaf.—Even leaf, fairly well twisted, has a good show of tip.

Special Comment.—This sample represents good merchantable tea and is probably worth about 1/6d. to 1/7d. if sold in London. The quality of the tea is similar to an Indian tea from the Cachar District.

At the Experimental Plantation, Cameron's Highlands a further area of about 5½ acres has since been planted up with the Betjan (3¾ acres) and Dangri (1¾ acres) varieties of tea.

A sample of 8 lbs. of hand-made tea produced from three-year-old plants grown at the Experimental Plantation, Cameron's Highlands, was forwarded to the Agent, Malay States Information Agency, London, on the 18th December, 1928 with a request that he would submit samples to one or two London Tea Brokers with a view to obtaining a valuation and report on the quality as compared with similar tea produced on the higher ranges in India and Ceylon.

Tea Growing in the Sungei Besi District of Selangor.

J. N. Milsum.

In view of the interest now being shown in the cultivation of tea in the Malay Peninsula, it is thought that a brief description of the cultivation of this crop and preparation of the product for consumption, by Chinese settlers, is worth recording. In the Sungei Besi District of Selangor, small areas of tea are frequently seen. There is a large Chinese population in this district on account of the extensive tin mining operations in the Sungei Besi Valley. In the Sungei Balak Chinese Settlement, which is an area of 360 acres adjoining the Sungei Besi—Cheras road, a considerable amount of land is under cultivation with tea, approximating 140 acres. Some tea is also cultivated at the Bukit Serdang Chinese Settlement at Sungei Ramal in the Kajang district.

Chinese Small-holders.

The Chinese small-holders in the Sungei Balak Settlement are Khehs and are familiar with the cultivation and preparation of tea as practised in China. The area of land occupied by each small-holder in the settlement varies from 2 to 5 acres, which is worked by himself and his family, but Chinese women are often engaged for plucking.

In addition to tea a variety of fruits are cultivated, including pineapples, Jack-fruit, rambutan, pulasan and coconuts. Certain of these trees provide some shade for the tea bushes, but generally no systematic shading is undertaken. The tea bushes under shade presented a more healthy appearance than those in full sun.

The settlement is situated on sharply undulating land with some steep hills. No silt-pitting or drains have been constructed with the result that considerable erosion of surface soil has taken place. On some of the steepest slopes the tea bushes are planted on narrow terraces. The soil may be described as a clay loam and is similar in appearance to the usual "bukit" land obtaining in Selangor.

Source of Seed.

Enquiries as to the origin of seed from which the tea bushes were raised elicited the reply that the original seed was brought over from China and planted in various districts in the locality, from whence the seed had been obtained. No regular seed-bearers were seen, but many of the bushes were flowering and fruits in various stages of maturity were observed. It was stated that seeds were sometimes collected for sale and realized about 18 cents per catty (13½ cents per lb.) A fair sample of such seeds was stated to give 50 per cent. germination under favourable conditions.

Appearance of Bushes.

The appearance of the bushes varies considerably, due to a certain extent to soil erosion. Further, plucking is coarse and irregular resulting in poor flushes. There was evidence, however, that many mixed "jats" comprised the bushes under cultivation. The mature leaf of the majority of bushes is small and the tips often of a reddish colour resembling what is known in Ceylon as "China jat". The leaf of others is considerably larger and in certain cases measure 5.5 ins. in length and 2.25 ins. in breadth. These bushes are robust and vigorous growing.

Nursery Beds.

Only one nursery of seedlings was seen, this was formed under the shade of fruit trees and sheltered with a rough "attap" fence erected round the beds. It was stated that the seedlings are allowed to remain in the nursery beds for six months when they are transplanted to the open land during favourable weather.

Method of Planting.

The land for planting is usually brought into cultivation from "lalang" and "blukar", there being little or no timber to burn off. The usual planting distance is 3½ ft. by 3½ ft. though frequently quite irregular planting is undertaken. Weeding is done as necessary, but "lalang" is evident and apparently only removed when it becomes heavy.

Pruning during the early stages of the seedling's growth is usually undertaken, but as plucking often commences when the seedlings are eighteen months old, the bushes have small chance of becoming well-formed. When the bushes grow to some size and commence to flower they are cut back to within 2 to 3 feet from the ground. This form of pruning was stated to be undertaken about every two years.

No contour drains or silt-pits were seen and for this reason the surface soil has suffered severely from erosion. Where erosion has been particularly severe the bushes are stunted and make little growth. The bushes are not manured in any way.

As already stated, plucking is said to commence when the bushes have been planted out for one year. This operation is usually done by Chinese women, who receive payment at the rate of 5 cents per catty (about 4 cents per lb.) of green leaf collected. The women are able to collect from 12 catties to 15 catties (16 to 20 lbs.) of green leaf per diem according to season and other conditions. Plucking is only done during the morning so as to enable the process of manufacture to commence during the afternoon. Fairly coarse plucking is undertaken and a large amount of stalk is allowed to go into the plucking basket. Plucking appears to be done about every ten days.

Method of Manufacture.

The apparatus used for the manufacture of the leaf into tea is simple. An iron pan, measuring 3 feet in diameter, as employed by Chinese for cooking rice, and costing about five dollars (Straits currency), is built over a brick or clay oven about 3½ feet square and 2½ feet high. No chimney is provided to take off the smoke from the wood fire. In some cases a second pan is built in at right angles to the first pan forming a hood. This allows the drying leaves to be stirred by means of a stirring-rod suspended above the oven, without the leaves falling over the side of the pan.

Various means are employed to dry the leaf, but it was stated that the best results are obtained by drying the leaf over a brisk fire without the aid of sun-drying. The system commonly in use is to wither the fresh leaf in the heated pan for about 20 minutes. The leaf is then removed and

rolled by hand in strong bamboo baskets or on a bamboo frame for about 20 to 30 minutes. The leaf is next placed in trays or flat baskets and put in the sun for about 6 hours. After this operation the leaf is sorted into two grades, i.e., tips and first leaf, and large leaf and stalks. Final firing then takes place over a brisk fire for 2 to 3 hours according to conditions. The leaf is constantly stirred and some skill is shown in doing this. The two grades of tea are then stored in empty kerosine tins until sold.

Yield of Dry Tea.

Very variable crops are obtained, but it appeared that about 30 catties (40 lbs.) of made tea per acre per month is an average crop throughout the year. It is considered that about 3½ piculs (466 lbs.) of dried tea per acre per annum is an average yield. The present price received locally for this tea is stated to be 68—75 cents per catty (51—56 cents per lb.) for the first quality leaf and 38—45 cents per catty (28—34 cts. per lb.) for the second quality. The price of this tea is stated to be lower than formerly owing to the present condition of the tin and rubber markets.

The principal buyers of locally produced tea are Chinese tin mine owners, who prepare and supply tea to their coolies working on the mines. It is stated that a demand for this tea exists in Penang and Seremban, where large quantities are forwarded.

Quality of Tea.

The prepared tea is greyish-green in colour and very rough in appearance. The first quality is composed of rolled tips, the first leaf and some stalks. The smell of the leaf is faint and rather smoky. The tea would pass through a half-inch mesh sieve. The infusion is light brownish-green in colour. Taste harsh and bitter. The second grade is mainly composed of portions of large leaf and stalks which would pass through an inch mesh sieve. The infusion is weaker than that from the first grade tea.

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Observations on Oil Palms.

T. D. MARSH.

In previous papers published in this Journal (1) and (2) the results were given of an experiment in the pollination of the oil palm, *Elaeis guineensis* Jacq., carried out at the Government Experimental Plantation, Serdang, during the years 1925 and 1926.

A summary of the above papers is given below:—

(1) An avenue of 86 oil palms of the Deli type, planted in May, 1922 in rows 36 feet apart at a distance of 30 feet apart in the rows, was utilized for a pollination experiment from the time they commenced to fruit (August, 1924) until the end of the year 1926.

(2) Forty three palms on one side of the avenue were pollinated artificially, while those on the other side served as controls.

(3) The yields of fruit from the two sets of palms were recorded.

(4) The records for the years 1925 and 1926 showed a much greater yield of fruit from the pollinated palms than from the control palms.

(5) The height, spread and circumference at the base of each palm were recorded and the average measurements of the two sets of palms showed no material differences in 1925 or 1926.

THIRD YEAR'S RECORD.

The present paper gives the results of a continuation of the observations to the end of the year 1927, together with comparisons drawn from the records of the two preceeding years.

The number of inflorescences artificially pollinated on each palm was limited, as in previous years, to a maximum

(1) Malayan Agricultural Journal, Vol. XIV. 1926, p. 384.
(2) *Loc cit.*, Vol. XVI, 1928, p. 20.

of one per month and only three palms out of forty-three artificially pollinated, as against fourteen of the naturally pollinated control palms, produced twelve or more bunches of fruit during the year.

A "bunch" was recorded whenever fruit was produced, even if the harvested weight of cleaned fruit was only one pound.

The number of artificially pollinated inflorescences which produced fruit was 253 out of a total pollinated of 331, which gives a pollinating efficiency of 76.4 per cent.

Allowing for the pollination of one inflorescence per palm per month, theoretically 516 inflorescences would have been pollinated, but palms failed to produce female inflorescences during many months of the year, consequently they did not have their maximum number of twelve pollinated.

The average number of inflorescences artificially pollinated was 7.7 per palm and the average number of bunches of fruit produced as a result of artificial pollination was 5.9 per palm.

It should be stated, however, that on the artificially pollinated palms a further 136 bunches of fruit matured as a result of natural pollination on palms which produced more than one female inflorescence per month during certain months of the year, thus giving an average production of 9.0 bunches per palm over the whole year.

The forty-three control palms averaged 9.1 bunches of fruit per palm for the same period.

The pruning of the palms was limited to the removal of those basal leaves whch were turning brown or yellow, it being assumed that at this stage they had ceased to function. Harvesting of fruit was not permitted to influence the rate of pruning. The stalks of fruit bunches were severed with a mallet and a sharp chisel, about three inches wide, the bunch afterwards being removed from the axil of the leaf.

The pressure of one or more leaves on the growing fruit did not appear to influence the development of the bunches, but often a bunch of fruit became large enough to exert sufficient pressure on the leaf immediately below for that leaf to touch the next lower leaf. The pressure, however, only occurred on one of the outside edges of the lower leaf and the tendency was for such leaves to be pushed to one side out of the line of the exerting force of the growing bunch of fruit.

The inflorescences of the oil palm are produced in the axils of leaves, in sequence from below upwards, following the production of leaves in the normal growth of the palm. It was observed in a few instances, however, that female inflorescences developed in the next higher whorl of leaves about two months earlier than those in the axils of lower leaves.

TABLE I.

Yields from Pollinated Palms, 1927.

Palm No.	No. of mature bunches.	Total weight of bunches. lbs.	Total weight of bunches. ozs.	Total weight of fruits. lbs.	Total weight of fruits. ozs.	No. of fruits.
1	8	201	4	133	10	5576
3	11	369	—	264	5	8812
5	9	348	—	231	15	8850
7	10	323	8	228	8	8485
9	10	300	8	207	14	8024
11	9	173	12	93	7	3985
13	6	113	8	72	3	3049
15	13	118	—	73	9	4516
17	11	143	—	96	15	3337
19	10	218	12	138	8	5473
21	9	275	—	189	12	5649
23	15	361	—	247	7	9326
25	9	160	12	103	12	4346
27	9	428	4	285	6	10934
29	10	80	8	55	3	4278
31	6	235	4	159	14	7424
33	12	228	—	156	4	7179
35	8	175	12	115	6	4036
37	12	399	8	281	9	8817
39	10	158	12	111	7	4122
41	1	21	—	15	—	440
43	8	152	10	104	6	4240
45	3	49	14	32	10	1598
47	14	251	8	156	14	5129
49	10	149	4	92	7	3253
51	9	169	—	113	4	4629
53	8	132	—	83	1	3130
55	10	153	14	101	3	4129
57	12	365	—	258	3	9862
59	10	158	12	94	6	3147
61	8	165	8	110	10	4416
63	10	149	12	100	12	3745
65	10	252	—	164	4	5305
67	11	300	14	204	11	7398
69	9	145	8	99	5	4466
71	7	162	10	114	15	3575
73	7	142	12	99	3	4479
75	7	138	4	90	12	3294
77	3	67	8	47	1	2083
79	8	172	12	116	1	6098
81	9	205	8	140	13	7057
83	10	171	10	108	9	3462
85	8	176	10	102	14	4992
	389	8,666	2	5,798	2	226,145

TABLE II.

Yields from Control Palms, 1927.

Palm No.	No. of mature bunches.	Total weight of bunches.		Total weight of fruits.		No. of fruits.
		lbs.	ozs.	lbs.	ozs.	
2	3	22	6	8	3	53
4	6	121	8	61	1	1042
6	4	26	8	3	—	130
8	3	21	4	11	9	460
10	9	132	10	63	11	1776
12	4	39	12	18	12	492
14	11	75	12	21	14	818
16	2	9	4	1	14	67
18	9	83	—	18	5	521
20	12	81	10	24	2	726
22	6	56	4	12	4	507
24	6	60	12	22	8	649
26	15	157	8	53	8	1621
28	18	326	6	166	10	5727
30	5	28	—	6	7	198
32	10	68	12	29	7	1209
34	6	60	4	21	3	752
36	9	78	14	32	—	1000
38	5	34	12	9	9	333
40	2	·10	12	3	—	78
42	5	84	—	45	10	2173
44	20	240	10	101	5	3123
46	3	22	12	6	10	213
48	3	21	8	4	8	148
50	5	36	8	16	8	588
52	11	158	6	78	15	2477
54	15	136	12	34	12	958
56	11	160	4	79	3	2469
58	14	107	6	24	3	733
60	20	315	—	134	5	4544
62	3	11	4	3	7	114
64	12	110	6	31	5	929
66	17	257	4	54	7	2209
68	13	87	—	35	14	1099
70	2	30	12	7	4	314
72	13	136	8	72	11	2244
74	10	159	12	80	2	3386
76	20	218	12	77	6	2754
78	11	50	4	20	5	1160
80	12	184	8	92	1	3837
82	—	—	—	—	—	—
84	3	32	—	7	6	508
86	13	107	10	27	9	1178
	381	4,165	—	1,614	11	55,267

TABLE III.

Summary of Tables I & II and Comparisons with 1925 and 1926 Yields.

Particulars.	1925		1926		1927	
	Artificially pollinated palms.	Control palms.	Artificially pollinated palms.	Control palms.	Artificially pollinated palms.	Control palms.
Number of palms -	43	43	43	43	43	43
Number of productive palms -	40	39	43	43	43	42
Number of bunches harvested -	349	137	546	407	389	381
Average number of bunches per fruiting palm -	8.7	3.5	12.7	9.5	9.0	9.1
Total weight of bunches -	3,116 lbs.	776 lbs.	7,821 lbs.	2,926 lbs.	8,666 lbs.	4,165 lbs.
Total weight of fruits -	1,951 ,,	379 ,,	5,163 ,,	902 ,,	5,798 ,,	1,615 ,,
Average weight of fruits per yielding palm -	48.8 ,,	9.7 ,,	120.1 ,,	21.0 ,,	134.8 ,,	38.5 ,,
Total number of fruits -	97,272	17,158	212,892	35,821	226,145	55,267
Number of fruits per lb. -	50.0	45.3	41.2	39.7	39.1	34.2
Average weight of bunches -	8.9 lbs.	5.7 lbs.	14.3 lbs.	7.2 lbs.	22.3 lbs.	10.9 lbs.
Average weight of fruits per bunch -	5.7 ,,	2.8 ,,	9.5 ,,	2.2 ,,	14.9 ,,	4.2 ,,

The figures in Table III show that there has been a progressive increase in yield from both sets of palms during the year, only one palm in the eighty-six under experiment failing to produce fruit.

The number of bunches harvested on each side of the avenue is less than that recorded during 1926, but the total weight of fruit produced is considerably greater. This suggests that as the palms get older, whether artificially pollinated or not, fewer bunches are produced per palm, but the average weight per bunch is greater.

During the year 1927 the control palms have almost doubled their yield over that of 1926. This is probably due to palms growing higher, consequently the leaves do not prevent the wind-borne pollen from reaching the flowers to the same extent as formerly.

The control palms have during 1927 increased their yield of fruit at a faster rate than the artificially pollinated palms, thus lessening the great disparity between the yields of the two sets of palms.

The increase in yield over that of 1926 of the artificially pollinated palms averages 15 lbs. of fruit per palm and is more than 250 per cent. heavier than that of the controls, or over 3½ times as great. During the year 1925 the ratio of the weight of fruit harvested from the two sets of palms was 5 to 1. The yield from the artificially pollinated palms is equal to the estimated production of palms over ten years old growing under average plantation conditions, although the system of artificial pollination is very moderate.

The amount of fruit harvested from the control palms is very low, but, as pointed out in previous papers on this experiment, it is in all probability due to the avenue conditions and general lack of pollen.

The size of the fruit has increased in comparison with previous years, as indicated by the number of fruits per pound. The control plot, which yielded the smaller number of fruits, has an average weight approaching half an ounce per fruit.

The average weight of cleaned fruit obtained from the artificially pollinated inflorescences during the year 1927 was 18.1 lbs. per bunch, but allowing for the additional 136 bunches which developed on the pollinated palms as the result of natural pollination, the average weight of fruit per bunch is reduced to 14.9 lbs.

The average weight of cleaned fruit from the control palms for the same period was 4.2 lbs. per bunch.

Measurements of Palms.

The following measurements of the palms on both sides of the avenue, taken at the end of the year 1927, are recorded:—

TABLE IV.

POLLINATED PALMS							CONTROL PALMS						
Palm No.	Height		Spread		Circumference at base		Palm No.	Height		Spread		Circumference at base	
	ft.	ins.	ft.	ins.	ft.	ins.		ft.	ins.	ft.	ins.	ft.	ins.
1	29	0	36	4	9	5	2	30	0	36	8	9	10
3	28	0	32	8	9	2	4	28	8	35	6	9	8
5	26	8	37	8	9	4	6	23	0	32	0	8	0
7	26	4	37	4	8	10	8	22	0	30	0	7	10
9	26	0	35	6	8	8	10	28	0	35	6	9	4
11	21	8	26	4	9	2	12	20	0	28	6	8	0
13	21	0	29	8	8	6	14	18	0	25	0	7	4
15	18	0	23	8	7	10	16	22	4	29	0	7	7
17	20	0	27	4	7	0	18	28	0	35	8	9	4
19	25	8	32	6	8	7	20	21	0	28	8	7	10
21	25	0	31	12	8	8	22	23	0	29	0	8	2
23	28	8	35	8	8	2	24	24	8	30	2	8	7
25	19	4	27	6	7	0	26	24	0	31	8	8	4
27	27	0	36	8	9	3	28	26	4	33	8	9	2
29	18	0	24	4	7	3	30	22	0	31	8	8	4
31	22	8	38	0	8	5	32	21	0	29	4	8	2
33	23	4	28	4	7	6	34	21	0	31	0	8	4
35	24	8	33	8	8	0	36	22	4	30	0	8	4
37	26	0	34	0	8	3	38	22	0	29	8	7	10
39	21	0	30	6	7	2	40	18	0	27	0	7	10
41	15	0	18	8	6	0	42	19	0	29	4	7	10
43	23	0	29	8	8	0	44	24	4	30	4	9	6
45	18	0	27	0	7	3	46	28	8	34	8	8	10
47	23	0	32	4	8	0	48	26	8	34	2	8	8
49	24	0	30	8	7	8	50	23	0	30	8	7	10
51	22	0	29	4	7	0	52	27	8	34	4	10	0
53	21	8	30	0	7	7	54	27	8	35	4	9	10
55	23	0	31	4	7	4	56	27	8	33	8	10	0
57	26	0	33	8	8	6	58	26	8	33	2	9	7
59	22	0	37	4	7	8	60	26	0	33	0	9	4
61	18	0	27	8	7	6	62	22	0	30	0	8	2
63	16	0	26	4	7	0	64	23	4	30	8	8	8
65	26	4	34	0	8	2	66	23	8	30	0	9	0
67	24	0	33	4	9	0	68	18	0	24	4	7	4
69	20	4	28	0	7	6	70	18	8	25	4	8	0
71	22	0	31	4	7	10	72	18	8	27	0	7	0
73	17	4	24	8	8	6	74	17	4	24	6	8	10
75	19	0	25	4	9	8	76	16	8	28	0	8	8
77	17	0	24	2	7	8	78	14	4	22	2	7	10
79	16	0	24	0	8	10	80	19	0	28	0	10	0
81	18	0	24	4	8	6	82	17	4	24	8	10	4
83	18	0	24	8	9	0	84	20	0	24	2	8	2
85	20	0	29	0	8	0	86	18	0	24	0	8	10
	947	8	1296	6	348	4		969	8	1291	2	370	1

The measurements recorded in Table III show the following comparisons with the figures recorded in 1925 and 1926:—

TABLE V.

Particulars.	1925		1926		Increase in growth during 1926.		1927		Increase in growth during 1927.	
	Pollinated Palms.	Control palms.	Pollinated Palms.	Control palms.	Pollinated.	Control.	Pollinated palms.	Control palms.	Pollinated	Control.
Average height of palms -	ft. 15.60	ft. 15.67	ft. 18.56	ft. 18.83	ft. 2.96	ft. 3.16	ft. 22.04	ft. 22.55	ft. 3 48	ft. 3.72
Average spread of leaves (i.e. diameter) -	21.49	21.70	28.16	27.78	6.67	6.08	30.15	30.03	1.99	2.25
Average circumference at base of palms -	6.45	6.63	7.19	7.57	0.74	0.94	8.10	8.61	0.91	1.04

The measurements summarised in Table V above show that the palms are well-developed for their age and that there is little difference in growth between the artificially pollinated and the non-pollinated palms, although the latter are slightly larger.

The heavy fruiting of the pollinated palms does not appear to have influenced the development of the palms to any great extent.

The increase in growth during the years 1926 and 1927 is recorded.

Comparison of Monthly Yield and Rainfall.

A summary of the total monthly yield of cleaned fruit obtained from the two sets of palms under experiment, together with records of the rainfall for the year 1927, are given in the following table:—

TABLE VI.

Summary of Monthly Yields and Rainfall Records, 1927.

Month.	Yield of Cleaned Fruit.						Rainfall Records.	
	Pollinated palms.		Control palms.		Total.		No. of wet days.	Total rain-fall.
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.		ins.
January -	205	1	25	1	230	2	21	11.15
February -	286	14	54	13	341	11	9	4.29
March -	502	4	116	6	618	10	16	13.82
April -	539	11	113	11	653	6	17	13.14
May -	455	4	76	11	531	15	6	6.49
June -	478	15	145	12	624	11	7	4.56
July -	470	13	60	8	531	5	3	1.11
August -	453	14	169	10	623	8	7	2.72
September	498	12	139	4	638	0	14	6.19
October -	745	15	343	11	1089	10	16	9.69
November -	697	—	217	8	914	8	14	16.09
December -	463	11	151	12	615	7	15	8.32
Totals -	5,798	2	1,614	11	7,412	13	145	97.57

Summary.

(1) The third year's yields of oil palms growing under avenue conditions in an experiment on artificial pollination are recorded, observations made, and comparisons are drawn with the yields of an equal number of palms naturally pollinated.

(2) Although the results still show a large increase in yield due to artificial pollination there was a slight reduction during 1927 of the great disparity between the yields of the two plots as recorded during the years 1925 and 1926.

(3) Measurements of height, spread and circumference at the base of individual palms are included. The average of the figures obtained from each side of the avenue show little difference in the size of the palms.

(4) The increase in the growth of the two sets of palms during the years 1926 and 1927 is given.

(5) A summary of the total monthly yield of cleaned fruit obtained from the two sets of palms, together with records of the monthly rainfall for the year 1927, are also given for purposes of comparison.

Publications of the Department of Agriculture.

The following publications may be obtained on application to the Office of the Director of Agriculture; and the Malay States Information Agency, Malaya House, 57 Charing Cross, Trafalgar Square, London.

A remittance to cover the cost should accompany applications; otherwise the Journals will be sent by post, Cash on Delivery, where that system is in force.

1. The Agricultural Bulletin F.M.S.

Vols. I—IV	(1913-16) VIII & IX	(1920-21)	price	$5.00 per volume.
Vol. V	(1917)	Nos. 1, 2, 3, 5 & 6	„	2.50 per set.
Vol. VII	(1919)	„ 2—6	„	4.50 per set.

(Vol. VI is out of print.)

2. The Malayan Agricultural Journal (continuing the Agricultural Bulletin) Published monthly.

Vol. X (1922) to Vol. XII (1924) price $5.00 per volume.

Vol. XIII (1925) to Vol. XV (1927) price $5.00 per volume or 50 cents per single number.

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3. The Handbook of Malayan Agriculture, price $1.00.

Current numbers of the Malayan Agricultural Journal and the Handbook may be purchased from the Singapore Branch of Messrs. The Federal Rubber Stamp Co.

4. *Special Bulletins.*

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36. "Red Stripe" Weevil of Coconuts (*Rhynchophorus schach*) by G. H. Corbett, 1924, 50 cts.
37. "Mouldy Rot" by F. W. South, and A. Sharples, 1925, 50 cts.
39. The Oil Palm in Malaya by B. Bunting, B. J. Eaton and C. D. V. Georgi, 1927, $1. Also published in M.A.J., Vol. XV, Nos. 9 and 10, 1927.

5. Warta Perusahan Tanah

Published in the Malay Language, distributed free from the Office of the Secretary for Agriculture.

6. Ma Loy Chow Nung Nyip Tsung Poh.

Published in the Chinese Language, distributed free from the Office of the Secretary for Agriculture.

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Further Experiments with Cotton in Malaya.

W. N. Sands.

In a previous number (1) of this Journal an account was given of certain experiments that had been made with long and short-staple cottons in Malaya. This work has been continued on a small scale to date with the object of preserving certain varieties and types which have been found to grow and bear well under local conditions, and also to provide the nucleus of a supply of selected seed for distribution should the cultivation of cotton be taken up at some future time in any part of the Peninsula. The results of these investigations are now published in order to place them on record for reference purposes.

A few small trials of selected strains have been made in different places locally, but, as a general rule, the results of these trials have not been encouraging. This was due in several instances to unsuitable soil; lack of knowledge of the crop and of the control of pests, as well as to the difficulty of ginning and marketing small quantities of lint and seed. It is doubtful whether cotton growing would prove as remunerative, in normal years, as the industries that are already established along the West coast of Malaya, but in the Northern and Eastern States, where the seasons are more sharply defined; where large areas are devoted to annual crops, and where the soil and rainfall are suitable, there appears to be no reason why a good class of cotton should not be grown. It would be necessary, however, in starting the industry to obtain expert advice and assistance in organising and prosecuting it in order to obtain the best results in the shortest possible time. Enquiries would also have to be made con-

(1) M. A. J. Vol. X Nos. 10, 11, 12. Oct.—Dec. 1928.

cerning the best markets for the class, or classes, of cotton it was decided to produce, and in this connection the possibilities of India, China and Japan, as well as Great Britain and the United States, would require to be explored.

The experiments conducted by the Botanical Division of the Department of Agriculture have been carried on continuously since the 1921 season, so that some of the varieties and strains have been under observation for the past seven years. In the Kuala Lumpur district, where the cottons were grown as annuals, planting has always been done towards the end of March or the beginning of April in each season. The rainfall of the months of April, May and June was usually ample for vegetative growth, whilst that of July, August and September was sufficiently low to enable the bolls to develop and ripen well.

The following cottons have been grown:

Sea Island	—	6 types.
Egyptian	—	4 ,,
Upland	—	5 ,,

together with certain varieties imported from India and elsewhere, or collected locally.

Of the six West Indian types of Sea Island cotton, two only have been retained for further trials in 1929: these are pure strains originally obtained from St. Vincent, West Indies, in 1921, under the marks USSI and AN. Both have made strong and healthy growth and have yielded well each season in small plots. They produce lint of good ordinary grade of this class of long-staple cotton.

Three Egyptian cottons, namely 'Assili' and two strains of 'Sakellaridis' have shown desirable qualities, and these also, are being preserved.

The Upland varieties tried have not grown well, and only the long-staple 'Acala', which was obtained from Nanking, China, appeared to be worth keeping.

None of the other introduced varieties such as Garo Hill, Uppam and Cambodia gave satisfactory returns, and besides, the lint was of low quality and value.

A long-staple cotton grown in Grik in Upper Perak, which resembled the 'Marie Galante' variety of the West Indies, was the best of those collected locally. It had no doubt been imported, originally, from India or Siam.

In the experimental plots the plants were grown singly in light, fertile and well-drained soil, and spaced at distances of 4 feet by 20 inches. In order to prevent cross-pollination by insects, all the flowers produced were closely tied with a piece of worsted before the petals opened. The flowers of the varieties grown, readily pollinated themselves successfully, although they were not allowed to open, so that no difficulty was experienced in 'selfing' them and obtaining fully developed bolls; nor was any deterioration in vigour or fertility noticeable in the progeny even after they had been self-fertilized for a number of years.

As soon as the bolls commenced to open, the plants of each type were examined to eliminate, if present, any accidental admixture of strains or 'rouges'. After this had been done, a few healthy plants which were fruiting well, were selected and labelled. The seed-cotton from each selected plant was carefully kept in a separate bag and afterwards critically examined in the laboratory to ascertain whether its seed-cotton, lint and seed characters were up to the required standard. This procedure was followed each year until this season when, owing to the length of time and labour required to make a detailed investigation of the numerous small lots of seed-cotton, it was decided to modify the practice somewhat. The quicker method now adopted is to examine and test the lint of each selected plant in a strain as hitherto, and then, if satisfactory, mix together, thoroughly, the seed-cotton from all the selected plants of that strain and take a representative sample from the bulk to obtain other data. As there was no cotton industry locally, this revised method was thought sufficient for present requirements, although not as reliable as the former in showing variations within a strain.

Characters of Lint and Seed of Selected Cottons, 1928.

Variety or Strain.	Mean maximum lint length in M.M. (1)	Lint Index (100 seeds) (2)	Average weight of seed in grms.	Weight of seed-cotton in grammes (100 seeds)	% Lint to seed-cotton (100 seeds.)	Remarks.
(1) Egyptian 'Assili' ...	31	6.79	.1305	19.840	34.22	Lint brown. Rather better than original selections.
(2) do 'Sakel' ...	40	5.19	.1326	18.450	28.12	Lint fine and long with slight brownish tinge.
(16) do do ...	39	5.51	.1447	19.980	27.55	do. do. do. Lint % rather low.
(5) Sea Island A. N. ...	48	5.84	.1489	20.730	28.19	Good ordinary long-staple Sea Island.
(6) do U.S.S. ..	45	5.25	.1120	16.450	31.91	Lint longer than original type. Lint rather short for Sea Island. Lint % high.
(24) Upland 'Acala' ...	34	7.47	.1435	22.020	33.92	Good long staple Upland.

(1) 25 Millimetres = 1 inch (approx.)

(2) Lint Index = the lint obtained from 100 seeds expressed in grammes.

No. 1 is a selected strain of the well-known Egyptian 'Assili' cotton. Its lint is brown, short, even and strong. The lint-index and ginning percentage are high. The bolls are small, but open widely rendering picking easy and rapid. It sells readily.

Nos. 2 & 16. are selected strains of the long-staple 'Sakellaridis' cotton which is grown so extensively in Lower Egypt and for which there is usually a large demand at good prices. The lint is fine and strong with a slight brownish tinge.

Nos. 5 & 6. are selected strains of West Indian ordinary Sea Island cotton. The lint is white, long, fine and strong, but at the present time the demand for it is limited. It realizes the highest market prices when saleable.

No. 24. is a good type of long-staple Upland cotton received under the name 'Acala' from Nanking, China. Its lint is white, fairly fine, even and strong and its lint index and ginning percentage are high. It would sell readily in quantity in most markets. Its seed is covered with fuzz, so that the seed-cotton would have to be saw-ginned to separate the lint from the seed, whereas the Sea Island and Egyptian varieties described above, are clean-seeded and would be roller-ginned.

Valuation of Cottons.

The Liverpool prices in December, 1928, for the cottons of the classes described above were—

West Indian Ordinary Sea Island	23^d-27^d	per lb.
'Sakel' Egyptian	$19\frac{1}{2}^d$	,,

With middling Upland at $10\frac{1}{2}$ pence per lb., the 'Assili' and 'Acala' cottons would probably be worth not less than 1/- per lb.

Hand-ginned samples were sent to cotton merchants in Shanghai for valuation, and the following report of Messrs. J. Spunt & Co., dated October 10th, 1928, is of interest.

No.	5.	Sea Island	—	$17\frac{1}{4}^{d}$	per lb.	c.i.f.	Shanghai.
,,	6.	do.	—	$18\frac{1}{2}^{d}$	do.	do.	do.
,,	1.	Egyptian 'Assili'	—	10^{d}	do.	do.	do.
,,	2.	,, 'Sakel'	—	$14\frac{3}{4}^{d}$	do.	do.	do.
,,	24.	Upland 'Acala'	—	10^{d}	do.	do.	do.

Messrs. Spunt state that "types No. 1, 2 and 24 would be suitable for the Shanghai Market as the mills in China are not organized at the present time to spin very fine counts". In this connection it may be mentioned that No. 16. 'Sakel', which closely resembles No. 2. 'Sakel', would be worth $14\frac{1}{2}$ pence on the above valuations.

Whilst most attention has been given to Sea Island, Egyptian and Upland cottons yet, as mentioned above, other species and varieties have been examined. The results of the examination were as under.

LINT AND SEED CHARACTERS OF CERTAIN OTHER COTTONS GROWN LOCALLY.

No.	Species or Variety.	Mean maximum lint length in M.M. (20 seeds.)	Lint Index. (100 seeds.)	Average weight of seed in grms.	Weight of seed-cotton (100 seeds in grammes.)	% Lint to seed-cotton. (100 seeds).	Remarks.
12	Garo Hill ...	23	2.95	.0600	8.950	32.96	Very short, coarse lint. Seeds densely covered with fuzz.
11	Kidney or Chain ...	26	6.46	.1474	21.200	32.81	Short coarse lint. Seeds clean but cemented together.
19	Cambodia ..	27	5.84	.1250	18.340	30.99	Resembles an American Upland variety. Lint fair. Seeds covered with fuzz.
18	Uppam or Tinnevelly	30	2.20	.0590	8.120	27.09	Lint fairly fine. Lint index low. Seed small and fuzzy.
14	Grik ...	38	4.60	.0755	12.150	37.86	Lint long and fairly fine. Lint % high. Seeds clean with a tuft of brown fuzz.

Garo Hill Cotton. (Gossypium arboreum var assamica. Watt). In the Garo hills the people make a peculiar kind of blanket from this cotton. It is of little commercial value, except to mix with wool, as the lint is coarse and short.

Kidney or Chain Cotton. (Gossypium brasiliense. Macf). is the perennial tree-cotton found throughout Malaya in gardens. The lint is rough and coarse and of lower value than American middling Upland. It is occasionally spun into yarn for weaving purposes locally, and is also used as cotton-wool for dressings. Watt[1] in his account of the early cultivation of this cotton states that "for many years past Brazilian or Kidney Cotton has taken a very subordinate position to Upland and Sea Island cotton and does not seem likely to recover ever again its lost popularity".

Cambodia Cotton. This cotton was obtained from Kuala Kangsar under this name. It was said to have been grown from imported seed. In lint and seed characters it resembled a long-staple Upland and was most likely a hybrid form of *Gossypium hirsutum. Linn.* and another species. Its lint was, however, inferior to standard long-staple Upland.

Uppam or Tinnevelly. (Gossypium obtusifolium var Wightiana, Watt). This is a well known Southern India long-staple cotton. The lint is fairly fine and long. The seed is very small and covered with fuzz. It is not as good as long-staple Upland. It grew very poorly in the local trials.

Grik Cotton. This name was applied to a cotton grown by the District Officer, Grik, Perak, in 1922. It was the best of the cottons found locally. It resembled the long-staple clean-seeded 'Marie Galante' cotton of the West Indies. Its origin was not definitely traced, but was supposed to have been brought from the Garo Hills some years previously. The flowers were of 3 types in respect to petal colour—

(a) Yellow, no blotch
(b) Cream, no blotch
(c) Yellow with dark red blotch.

The seed was clean and free. The style much exceeded the stamens. The lint was fine and long and ginning percentage high. It was almost equal to long-staple Egyptian in quality.

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[1]Watt. Sir George. 'Wild and cultivated cottons of the World,' 1907.

The photograph, Plate (1), depicts a combed seed of each of the cottons named and described so that they can be compared with each other.

In the absence of large field trials under suitable soil and climatic conditions, it is difficult to give a reliable estimate of the yields likely to be obtained with selected varieties; still there appears to be no reason why 200 to 250 lbs. of lint per acre should not be obtained in average seasons.

The chief pests that have caused some damage to the plants in certain seasons were—

(a) the larva of the moth, *Sylepta derogata.* F. which eats the leaves and rolls itself in them.

(b) the larva of the small moth, *Earias fabia. Stoll.* which bores into, and destroys, young shoots and also bores into the immature bolls and feeds on the contents of them.

(c) the cotton-stainer, *Dysdercus cingulatus.* F. which feeds on the seed in unopen and open bolls. The staining of the lint is due to micro-organisms which follow this sucking insect's attacks on the young boll.

Several other pests have been noticed causing minor damage, but the ones named above were those which were usually present. The pink-boll worm, *Platyedra gossypiella,* Saund, which is a major pest in many cotton-growing countries is said to occur locally, but has not yet been observed.

The control of insects such as the above-named is of prime importance in cotton-growing, and, unless effective methods are adopted to destroy and keep the pests in check, the industry is not likely to succeed.

Summary.

(a) A short account is given of trials made with Sea Island, Egyptian, Upland and other cottons in Malaya.

(b) It is stated that trials generally have not been encouraging due chiefly to unsuitable soil, lack of knowledge of the crop and methods of controlling pests as well as to the difficulty of ginning and marketing small quantities of lint and seed.

(c) More favourable soil and climatic conditions for cotton-growing are believed to exist in the Northern and Eastern States of the Peninsula than elsewhere, but expert advice and assistance should be made available to growers there if it is desired to establish the industry along the right lines.

(d) It is mentioned that certain selected self-fertilized strains of Sea Island, Egyptian and Upland cottons have been grown experimentally for the past seven seasons without any deterioration in the vigour of the plants or quality of lint.

(e) The characters of the seed-cotton, lint and seed of selected strains are given, together with market valuations of the lint they produce. Notes are included on the characters of certain other cottons grown locally.

(f) The chief pests so far observed attacking the plants and bolls are mentioned.

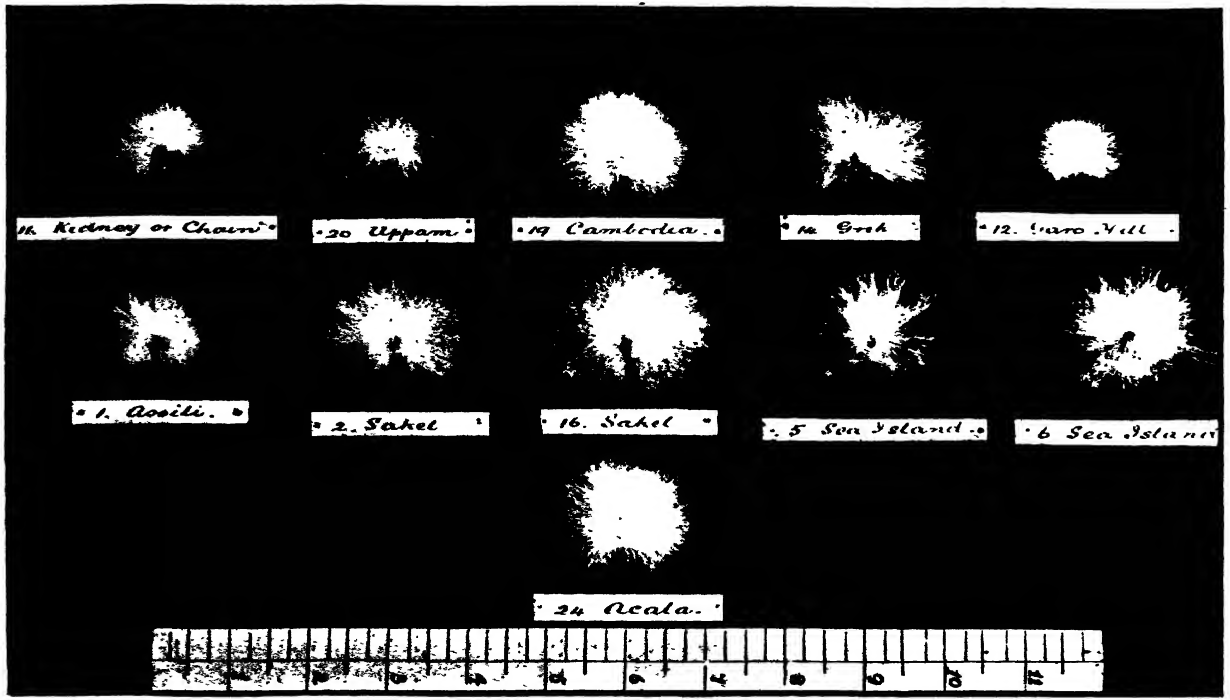

FIG. 1. UPPER SERIES.—Seed-cotton of varieties collected locally.
LOWER SERIES.—Seed-cotton of Selected Strains of Sea Island, Egyptian and Upland varieties.

Variation in Coconuts.

By H. W. Jack.

This brief note is supplementary to an article on "Variation in Coconuts" which was published in M.A.J. Vol. XV. No. 11, 1927 and which showed the frequency table of variation in fruit production of coconut palms over a period of seven years. The present note merely brings that table up to date for a total period of eight years, and further emphasises the conclusions already reached regarding variability in fruit production with this crop.

Those conclusions may be cited once more for convenience as a summary, but reference to the previous article above mentioned is invited.

The writer again expresses the gratitude of the Department of Agriculture towards the Staff of Jugra Lands and Carey Ltd. for their continued facilities in the maintenance of the records on which this note is based.

Summary.

1. The coefficient of variability of fruit production of an average population of coconut palms is 34% of the mean production.

2. The variability in cropping per palm per annum ranges from 5 to 115 fruits on the block under observation containing 471 palms growing under apparently uniform conditions.

3. 19% of the palms on an average coconut plantation are not profitable.

4. 15½% of the palms on an average plantation produce 24½% of the total crop.

5. Poor yielding palms remain poor yielders, and high yielders are constantly high yielders.

TABLE.

This table shows the group frequencies of the average production of fruits per palm per annum over a continuous period of eight years.

Groups.	F.	F x G.	d.	d^2	Fd^2
5	1	5	54	2916	2916
15	11	165	44	1936	21296
25	34	850	34	1156	39304
35	44	1540	24	576	25344
45	65	2925	14	196	12740
55	88	4840	4	16	1408
65	83	5395	6	36	2988
75	71	5325	16	256	18176
85	35	2975	26	676	23660
95	32	3040	36	1296	41472
105	5	525	46	2116	10580
115	2	230	56	3136	6272
N = 471		F x G = 27815		ΣFd^2 = 186156	

Mean = Σ F x G ÷ N = 27815 ÷ 471 = 59.09, say 59.

Standard Deviation = $\sqrt{\frac{\Sigma F.d^2}{N}} = \sqrt{\frac{186156}{471}} = \sqrt{395.24} = 19.88$

Coefficient of variability = $\frac{S.D. \times 100}{M} = \frac{19.88 \times 100}{59} = 33.6949$ say 34 %

Marketing Rubber Seed.

D. H. Grist.

Previous Investigations.

The value of the oil contained in rubber seed has been appreciated for many years. The Bulletin of the Imperial Institute Vol. XI No. 4, 1913, contains the results of the investigations of rubber seed oil; and the Agricultural Bulletin of the F.M.S. Vol. VI No. 5, 1918, contains an article on "The oil content, keeping qualities and commercial possibilities of para rubber seed". While it is not the purport of the present article to deal with this side of the question, it may be of interest to state briefly the potential value of this bye-product of the rubber industry.

Rubber seed consists of approximately 37 per cent of shell, and 63 per cent of kernel. The oil content of the kernel is about 50 per cent, while that of the whole seed is about 25 per cent.

Certain correspondents have enquired regarding the manurial value of rubber seed. As far as the writer is aware, no work has been carried out on this subject. The following analyses were published by the Department of Agriculture in 1918.

Total ash on husks	0.70 per cent.
,, kernels	1.83 per cent.

Ash Analysis.

	Husk	Kernels
Percentage Potash (K_2O)	38.6	37.2
,, Phosphates (P_2O_5)	16.8	28.6

The nitrogen content on dry shells is 0.22 per cent, and of dry kernels 2.45 per cent.

The above figures are based on samples of sound clean seed. Seed collected for export for the extraction of oil does not reach this high standard, as it contains a proportion of empty seed, and seed in bad condition.

One firm reports as a result of their experience in handling several thousands of tons, that they obtain,—kernels 46 per cent, shells 42 per cent, loss of weight 12 per cent on the weight as shipped. They further state that on a commercial scale the yield of oil from the kernels is 45 per cent, and from the whole seed 19 per cent.

The conclusions of the Imperial Institute were as follows:—

> "Though para rubber seed oil is a drying oil it dries less quickly than linseed oil, and is therefore inferior to this oil for those industrial uses to which linseed oil is particularly suited. When linseed oil is high in price, however, it has to be replaced by oils that are intrinsically inferior to it for these purposes, and in such cases Para Rubber seed oil would be a valuable substitute. The defects of Para Rubber seed oil from this particular point of view are, however, advantages for other industrial purposes, since they enable it to be used to some extent in industries in which the employment of linseed oil is inadmissible. On the whole, the results of these trials clearly indicate that there would be no difficulty in finding a market for Para Rubber seed oil, provided it can be put on the market at a suitable price and in large quantities. In this connection mention may also be made of the fact that the new process of "hardening" liquid oils by hydrogenation if successful on a commercial scale, will open an entirely new market to oils of the Para Rubber seed type".

The Department of Agriculture in 1916 consigned 30 tons of the seed to Hull for crushing and valuation; £50 per ton was obtained for the oil and the residual cake realised £8 per ton. At the time, linseed oil stood at £60 per ton.

The difficulties in these earlier attempts of marketing Para Rubber seed were many, including that of obtaining adequate shipping facilities, scarcity of labour, and lack of organisation.

An attempt was made to prepare the oil locally with a plant erected for the purpose. This venture proved unsuccessful.

Revival of Industry.

The question of deriving profit from the rubber seed produced in Malaya has recently received renewed attention owing to the offer of an American Corporation to purchase the seed. Briefly, the offer was to purchase such seed at $22* per ton f.o.r., sacks to be provided by the Corporation. The seed collected is exported to Belawan, where it is decorticated, the kernels are dried, chemically treated to kill enzymes, bagged and shipped to America where the oil is extracted. The export of rubber seed from Malaya for 1928, as shewn in the returns of the Registrar of Imports and Exports, amounted to 7,905 tons, valued at $246,940. Correspondence in the Press shewed that there was a divergence of opinion amongst planters as to whether rubber seed could be marketed profitably at this price. In view of the importance of the subject, this Department has undertaken an independent investigation, with the concurrence of the Rubber Research Institute. The conclusions which follow are compiled from a study of the facts supplied by the managers of thirty-six estates who have been engaged in the collection and export of rubber seed during the seed season 1928. The writer takes this opportunity of thanking these estates for the assistance they have rendered in this enquiry.

Yields of Rubber Seed.

Messrs. Spring and Day in 1918 collected seed from four estates (age not mentioned) which gave an average of 330 lbs. of seed per acre. They estimated the yield at 300 lbs. per acre, but pointed out that there was a seasonal variation to be taken into account.

Mr. Gotwaite of the Prosco Oils Corporation estimates the highest yield at 250 lbs. per acre, and the lowest at 100 lbs. per acre, from which he deduces an average of one ton of seed per 10 acres.

Returns of the rate of seed collected per acre were received from 10 estates; excluding one return, the average was one ton to 18 acres. It is to be noted that the season was generally considered one of little seed production.

* Straits Settlements Currency $1/- two shillings and four pence.

The question of rate of payment for collection must also be taken into account. If the rate is too low when seed is scarce, the full amount will not be collected. It is as well therefore to regulate price for seed according to the ease of collection, i.e. by raising the price as the quantity collected decreases. As an instance of this system, may be quoted the following from one estate:—

> "At first I paid at the rate of 6 cents per kerosine tin and 26 tons were collected at this rate. Later I increased the rate to 7 cents per kerosine tin and got a further 20 tons. Again I had to increase the rate to 8 cents per tin which resulted in a further 7 tons".

The cost of collection in this instance averaged $8.37 per ton. It is probable, therefore, that the average of one ton to 18 acres does not represent the maximum obtainable, but is governed by the amount that it was profitable to collect.

The amount of seed that is produced in the country, based on one ton to 10 acres and 2¼ million acres of rubber is 225,000 tons, but it is impracticable to collect the total amount produced. Land cultivated with a cover crop may be ruled out, while transport costs may be prohibitive in some districts. In addition, collection on hilly land seems less attractive to collectors; and in other instances, alternative and more profitable forms of spare time labour prove serious competitors to rubber seed collection. It is probable, however, that about 100,000 tons per annum of rubber seed could be economically marketed, which at the present price is worth $2,000,000.

Collection.

Cost of collection is the largest item in marketing rubber seed. It is noticeable that on the large majority of estates Indian labourers are used for this purpose, although instances occur where Malays, Javanese and Chinese have been successfully employed. The average amount paid for the task is 5 cents per kerosine tin, or half a cent per kati. The actual amount offered for collection has varied somewhat according to the main object of the manager concerned. In some cases the marketing of rubber seed is looked upon merely as a commercial proposition, in which case the cost of collection is kept at a minimum; in other cases, it is treated as a spare time occupation and the rates are raised so that the labourers

can take a share of the profits, while on one estate the profit derived was used solely for the benefit of the coolies by being given to the estate Temple Fund. Figures of the cost of collection obtained from twenty-eight estates average $9.30 per ton, with a range from $6.00 to $14.00 per ton.

It is generally considered advisable either to pay cash for daily delivery or make a weekly payment; this system seems to apply to all estates from which favourable replies have been received.

Packing, Weighing, Labels, Twine.

The average cost of these operations on the twenty-five estates that give figures shews a wide variation, from the lowest—8 cents per ton—to the highest—$2.89 per ton. It is probable that the higher figures include other charges peculiar to the estate concerned. The average cost, however, on 25 estates, is 87 cents per ton.

Supervision.

There was a divergence of opinion as to whether, if no extra supervision charges were incurred, any cost of marketing should be debited under this head. It is correct to charge a certain amount to supervision for this work and to reduce the amount under this head in the cost of rubber production. Nine estates only included supervision under the charges of rubber seed production—the average cost being 88 cents per ton.

From the experience of the past season, it is evident that closer supervision is essential. Consignments of seed have been held up at port because they were in such a condition that they could not be certified as being free from pests and diseases. The lack of supervision was evident by the presence of a large proportion of empty and dirty shells, old and mouldy seeds, the introduction of quantities of foreign matter in the shape of earth, leaves and twigs of rubber, while in many cases seed was packed in wet bags, and being necessarily consigned in closed railway trucks, very considerable heat was generated, resulting in active germination of sound seed *en route*. These difficulties would be obviated if managers instituted some control over the condition, packing and despatch of collections.

In this connection it should be explained that no regulations governing the export of plants or parts of plants in general and of rubber seed in particular are imposed by the local Government. Most countries, however, have brought into force Rules governing the importation from foreign countries of living plants, parts of plants and seeds, in order to reduce the danger of introduction of pests and diseases not previously existing in the importing country. Almost all such rules require that consignments of plants and seeds shall be accompanied by a certificate of freedom from pests and diseases signed by a properly qualified officer in the exporting country. Such a certificate is required by the Government of the Netherlands East Indies to accompany each consignment of rubber seed. It has been arranged that before granting such a certificate ten out of each 100 bags of seed shipped will be inspected by an officer of the Department of Agriculture at the Malayan Port from which the seed is being despatched. If the rubber seed is found to be covered with earth, which may itself convey infection, or to consist of a high percentage of old partly empty shells with shrunken and mouldy contents, it is obvious that the required certificate cannot be signed in good faith. If the consignment cannot be granted a certificate it will be refused entry into Belawan and it is, in consequence, useless to despatch it. If part of a mixed consignment is in a bad condition that portion must be removed before the required certificate for the remainder can be signed.

Transport.

The amount spent on transport naturally shewed great variation. The average cost of all operations other than transport is approximately $11 per ton. With the selling price at $22, the sum of $11 remains from which transport and profits are to be found. It remains therefore a case for individual consideration as to whether the estate is so situated as to make a profit possible. Twenty six estates gave their figures for transport, the lowest was 26 cents per ton, while the highest was $7.50 per ton. All of these estates marketed their seed at a profit. The estate with the lowest transport cost made a profit of 123 per cent, while the estate with the highest transport cost (but lower cost of collection) made a profit of 47 per cent. The average transport expenses of twenty three estates was $2.61 per ton.

Total Costs.

The average costs, so far as figures are available, for the collection and marketing of Para rubber seed are as follows:—

Collection	...	$9.30	(28 estates)
Packing etc.	...	.87	(25 ,,)
Supervision	...	.88	(9 ,,)
Transport	...	2.61	(26 ,,)
		$13.66	

Therefore the average profit amounted to 67 per cent. The estate with the highest profit made 160 per cent, while only three estates reported a loss, due to conditions peculiar to the estates in question.

Value of the Industry.

It has been proved that if the seed can be collected at from 5 to 8 cents per kerosine tin, a profit can be made depending upon the distance of the estate from the railway station.

Taking the above figures as a basis, the value of rubber seed amounts to fifty cents per acre per annum. To this, as has been pointed out by many correspondents, may be added a small amount which represents the amount saved on weeding costs. This is estimated at from 15 to 20 cents per acre per annum.

The benefits of this industry cannot be judged by the profit and loss account alone. Eighty per cent of the estate managers who have written on this subject point out that the scheme is of assistance in keeping a contented labour force, providing work for women and children (generally a problem on an estate with Indian labour), and thus being of especial assistance to labourers with large families.

Conclusions.

The marketing of rubber seed, at present prices, is profitable providing that transport is not prohibitive, the estate

has a settled labour force, is clean weeded, and not too steep; and that there are not more remunerative forms of spare time employment for the coolies.

The average cost of production allows a profit of over 50 per cent to the estate.

The work is popular amongst labourers and their families, who are thus able to add considerably to their wages.

Planters have gained valuable experience during the past season in maketing rubber seed, and it is anticipated that improved returns will result in future seasons from a closer supervision of the collections.

Received for publication 14th February, 1929.

Preliminary Report on the Cultivation of Aleurites Montana.

J. N. Milsum and T. D. Marsh.

A small area of land at the Government Plantation, Serdang, was planted with seedlings of *Aleurites montana*, Wils., a Chinese Wood Oil Tree, early in 1925. The object of this paper is to record the growth and behaviour of these trees up to the end of the year 1928.

A description of the tree has already been published in this Journal (Vol. XII, January, 1924, No. 1, p. 1. "Candle-nut and Chinese Wood Oil Trees").

In a subsequent paper (M.A.J., Vol. XVI, August, 1928, No. 8, p. 296) a report, prepared by the Chemical Division of the Department, was published on the oil content of seeds harvested at Serdang, together with the analytical constants of the oil.

Source of Seed.

The seed was obtained from the Botanical and Forestry Department, Hong Kong. One consignment weighing 4 lbs. 4 ozs. and containing 750 seeds, was received in December, 1923 and another weighing 4 lbs. 10 ozs. and containing 735 seeds, was received during November, 1924.

Germination of Seed.

The first consignment of seeds was sown in seed-boxes, containing prepared soil, on the 8th December, 1923. Germination commenced six weeks later and continued for a period of nearly three months. The seeds, however, were not in good condition and only 15 per cent. germination was obtained. The young seedlings were lifted from the seed boxes and planted in small bamboo baskets and kept under shade. As there was insufficient stock for planting the area set aside for this tree, the young plants were subsequently transplanted into pots and retained until the plants raised from the second consignment were large enough to plant out in the field.

The second consignment of seeds was sown in boxes on the 18th November, 1924. Germination commenced a month after sowing the seeds and continued for nearly two months. In this instance the seeds were evidently in better condition as 45 per cent. germination was recorded. The seedlings were planted in bamboo baskets when large enough to transplant from the seed boxes.

Planting in the Field.

The land allotted to this crop comprised an area of 3½ acres, situated at the base of a somewhat steep hill in the centre of the plantation. The soil may be described as a heavy laterite loam.

The area was lined and holed at a distance of 20 feet by 20 feet square planting, allowing 108 trees to an acre. Large-sized holes were dug, and in view of the fact that the land had been under cultivation for several years and consequently had suffered to some extent from erosion, a basket of cattle-manure was added to each hole.

Plants raised from both consignments of seeds were planted out during March, 1925. A number failed to become established and during the ensuing planting season (November, 1925) it was necessary to replant 20 per cent. of the holes.

A cover crop, *Calapogonium mucunoides*, was then established over the area, but did not prove a complete success owing to the land having been opened for some considerable time.

Growth and Habit of the Trees.

After planting growth was rapid, especially in the case of the trees planted on the lower part of the area. One tree flowered in March, 1926 and a few mature fruits were collected in April, 1927, i.e., two years after planting in the field. A number of trees flowered during 1927 and a few pounds of seeds were collected during that year. Early in 1928 more trees flowered and in the following June about 35 lbs. of dried seeds were harvested from five of the largest trees. In August, 1928 a number of trees were flowering freely and at the close of the year the majority of trees had

Aleurites Montana, four years old, at the Experimental Plantation, Serdang.

reached the flowering stage and a number of trees were bearing fruit. One such tree was observed to be bearing about 100 fruits.

Flowering and fruiting occurs throughout the year, but flowering is heaviest during the dry seasons of the year, i.e., January/February and July/August.

. Great variability exists in the shape of the leaf of the trees. Certain trees have almost all cordate leaves, while others are palmately five-lobed. Shoots from the trunk usually have palmate leaves.

The flowers are glistening white when they first open. but later show a deep pink centre. The individual flowers are 2.25 inches in diameter and produced in large terminal racemes on the shoots of the previous season's growth.

After flowering, the stem of the female inflorescence becomes woody in order to support the fruit.

The fruits turn black as they mature on the trees and fall to the ground. The husk of the fruit then splits open from the base upwards and the seeds are readily extracted. About 160 seeds, after sun-drying, weigh one pound, which is approximately the same weight as the seeds originally received from Hong Kong.

Usually only three to four fruits mature on a single raceme, but recently a greater number have been noticed, totalling fifteen in some cases.

The fruit generally contains three seeds, but specimens containing four seeds are often obtained.

The average height of the trees at the close of the year 1928 was 15 feet, though a number of specimens exceeded 20 feet. The average spread, i.e., the distance from the trunk to the outermost branches was 7 feet. The circumference, at 2 feet from the ground, averaged 16 inches. A number of the largest trees, however, exceeded 24 inches, (see Plate I).

Aleurites montana is stated to be indigenous to South Eastern China, being found in the Province of Fokien southward to Tongking (see *Kew Bulletin*, 1914, p.1. "The Wood-oil Trees of China and Japan"). It would appear, therefore,

that the climate of the Malay Peninsula, with its continuous high temperature, would be unsuitable for complete success with this species. The growth of the trees at the Government Plantation, Serdang, supports this supposition.

The behaviour of the individual trees is erratic and specimens are to be found flowering, fruiting, and wintering at the same time. It is thought that the lack of a definite cold season in Malaya causes this phenomenon. Generally speaking the trees appear to be unaccustomed to local climatic conditions. The trees have produced numerous lateral suckers during the whole period of their growth, which were removed periodically. It is possible that this species would show a more vigorous growth at high elevations in Malaya.

Bud-Grafting on Indigenous Stock.

In view of the behaviour of the trees an attempt was made early in 1928 to bud scions of *Aleurites montana* on to stocks of the indigenous *A. triloba*, Forst., the candle-nut.

The method employed was a form of "patch budding". A total of sixty-five stocks were so budded and twenty-seven showed every signs of being successful. After the upper portion of the stock was cut back a growth of 1 to 2 inches took place and a number of the successfully budded plants were removed to the field. All these trees, however, as well as those remaining in the nursery, died during the subsequent dry season.

The stocks were rather old and it is thought that complete cutting back of the young trees after the buds had become united was too severe. It is intended to proceed further with experiments on these lines.

Pests and Diseases.

After a complete stand was established no trees were lost from either pests or diseases. The trees, however, have been periodically attacked by a large Case worm (*Psychid* sp.) and on some occasions this pest has assumed serious proportions, but has been kept in check by hand-picking. So far no disease has been observed amongst the trees.

General Remarks.

Although the trees under reference have made comparatively rapid growth and are now producing fruit, the indications are that this species of Aleurites is not altogether suited to the conditions prevailing on the plains in this country. It will, however, take some time to decide this point. In the meantime it is proposed to proceed further with the bud-grafting experiments.

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Baker Memorial Professorship.

The Board of Regents of the University of the Philippines has established a Baker Memorial Professorship in the College of Agriculture. This professorship is in memory of Charles Fuller Baker who was dean of the College of Agriculture from 1917 until his death in July, 1927.

This professorship provides for the services in the College of a man from abroad who shall be in residence in the College eight months at least and shall carry a teaching load of five hours a week. It is the purpose to secure men who are specialists in the different sciences allied to agriculture. This professorship in honoring Dean Baker provides for incalculable benefit to the College which in itself is a fitting tribute to a man whose services to the College were so valuable.

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Phytophthora Species in Malaya.

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The following account is a record of further progress in the study of local species of *Phytophthora* concerning which a preliminary report was published in February, 1928. (1) With the exception of two species, all the local species in culture have been isolated from *Hevea brasiliensis* (H.B.K.) Muell—Arg., from the diseases known as Black Stripe, Patch Canker, and Pod-rot. The results prove that several species of *Phytophthora* are directly responsible for these diseases in Malaya, while experiments with certain other species from different hosts indicate that they also may be causal organisms. The other two species of *Phytophthora* were isolated from a disease of Roselle fibre (*Hibiscus sabdariffa L. var. altissima*), and from a disease of Sireh—the betel vine (*Piper Betle L.*). Diseases caused by *Phytophthora* are of importance in Agriculture all over the world, and, since our knowledge of the local species is scanty, it is desirable to gather together some facts concerning this genus in Malaya.

In addition to the crops mentioned above, *Phytophthora* species are known to attack coconut palms, and areca palms, castor oil, tobacco, tomato, and potato plants, nutmeg, cinnamon and citrus trees, and other tropical crops. A knowledge of the local species is therefore of the greatest importance, in case of any of these crops become attacked by a *Phytophthora* species.

The fungus *Phytophthora* reproduces by means of sexual and non-sexual spores. The sexual spores, called oospores, are not always formed by the different species, but, when formed, they serve to carry the fungus over a period of unfavourable conditions such as drought. The non-sexual spores are of two kinds—sporangia and chalmydospores—and are normally aerial. The sporangia require the presence of moisture in order to form motile bodies called zoospores, which are considered to be the means by which the fungus spreads rapidly. Zoospores are formed inside the sporangia and escape singly or in groups through the papillae. (Plate 3). They possess cilia by means of which they swim about in the water. After a short active period they come to rest and germinate, and, if they are near a suitable host plant, the germ tube penetrates through the epidermis and the the plant may become diseased. Sometimes the sporangia germinate directly without forming zoospores, in which case the germ tubes from the sporangia may start the infection. Chlamydospores are thicker walled than sporangia and do not germinate readily. They are not formed by every species, and, like oospores, act as resting bodies which can withstand unfavourable conditions. They do not form zoospores, but germinate directly.

Since the spread of the fungus *Phytophthora* is largely controlled by the presence and absence of moisture, epidemics of diseases causes by the fungus do not appear in dry weather.

In the following pages, reference is frequently made to *Hevea*. Since only one species of *Hevea* is concerned—*H. Brasiliensis* Muell.--the name *Hevea* refers to this species.

HISTORY OF THE LOCAL AND OTHER SPECIES OF PHYTOPHTHORA.

The disease known as Black Stripe of *Hevea* was first recorded in Malaya in 1916 (2). This was the first record of a *Phytophthora* sp. causing a disease of an economic crop in this country.

In 1918 R. M. Richards isolated a fungus, which he considered to be a *Phytophthora* sp. from Patch Canker of *Hevea*. A description of this fungus was not published, but, in a report to the Brown Bast Investigation Committee, of which he was a member, Mr. Richards stated that "from the characters of the antheridium, and its relationship to the oogonium, it is clear that my fungus must be placed in the 'cactorum' group." Also, in a letter to the Secretary of the

above Committee he mentions a series of inoculations in which he had to use "oospore material" as all his cultures were in that condition. This is the only record of a local species with paragynous antheridia, and it is possible that Richards was dealing with a *Pythium* sp. isolated from Patch Canker of *Hevea* by the writer in 1924 (3).

In 1925 the writer obtained a *Phytophthora* from Sireh (*Piper Betle* L.) A note on this fungus was published in 1926 (4) and again in 1928 (1). This species has been identified as *Phytophthora colocasiae* Rac.

In the same year two different species of *Phytophthora* were isolated from two bark diseases of *Hevea* i.e Black Stripe and Patch Canker. The species from Black Stripe was obtained from Malacca and was identified as *P. palmivora* Butl.,* and the species from Patch Canker was obtained from Selangor. These two fungi are entirely different in their growth in culture. About the same time *P. palmivora* Butl. was isolated from Patch Canker of *Hevea* in North Perak. It was indistinguishable from the strain from Black Stripe of *Hevea* in Malacca. This species was again isolated from Black Stripe of *Hevea* in Chemor, Perak, in 1928.

In 1927 the writer obtained a *Phytophthora* from some diseased *Hevea* pods in Selangor. This fungus produces oospores with amphigynous antheridia, in large numbers in culture, as well as sporangia. It is a new species.

In 1928 this fungus was again isolated from Black Stripe of *Hevea* in Malacca. In this year also another *Phytophthora* was obtained from Black Stripe of *Hevea* in Negri Sembilan, and yet another was isolated from a disease of Roselle fibre (*Hibiscus sabdariffa var altissima* L.)

This concludes the list of the local species which have been obtained up to the present.

In addition to the local species a number of other *Pytophthorae* have been obtained and grown in culture, in this

* Formerly known as *P. faberi* Maubl.

laboratory, to assist in comparing the different species. For convenience, all the species have been numbered as follows:—

No. 1	*P. palmivora* Butl. Malacca S.S. Black Stripe, *Hevea.*	1925.
No. 2	*P. palmivora* Butl. Chemor, Perak, F.M.S. Black Stripe, *Hevea*	1928.
No. 3	*Phytophthora* sp. Negri Sembilan F.M.S. Black Stripe, *Hevea.*	1928.
No. 4	*Phytophthora* sp. Malacca, S.S. Black Stripe, *Hevea.*	1928.
No. 5	*Phytophthora* sp. Selangor F.M S Pod-rot, *Hevea.*	1927.
No. 6	*Phytophthora* sp. Selangor F.M.S. Patch Canker, *Hevea.*	1926.
No. 7	*Phytophthora meadii* McRae, India, Pod-rot and leaf fall of *Hevea.*	1928.
No. 8	*Phytophthora* sp. Selangor F.M.S. Wilt, Roselle fibre (*Hibiscus sabdariffa* L.)	1928.
No. 9	*P. colocasiae* Rac. Pahang F.M.S. Wilt of Sireh (*Piper Betle* L.)	1925.
No. 10	*P. colocasiae* Rac. U.S.A. via Kew	1926.
No. 11	*P. palmivora* Butl. India, Bud-rot, Coconut Palm.	1924.
No. 12	*P. arecae* Coleman, India, Areca Palm.	1928.
No. 13	*P. parasitica* Dastur, India, Castor Oil.	1928.
No. 14	*Phytophthora* sp. India, *Piper Betle* L.	1928.
No. 15	*P. nicotianae* B. de H. Florida, Tobacco, via Kew.	1926.
No. 16	*P. nicotianae* B. de H. Sumatra, Tobacco.	1928.
No. 17	*P. nicotianae* B. de H. Java, Tobacco, via Kew.	1926.
No. 18	*P. palmivora* Butl. Jamaica, Coconut Palm, via Kew.	1926.
No. 19	*P. palmivora* Butl. St. Vincent, Cotton, via Kew.	1926.
No. 20	*P. palmivora* Butl. Trinidad, Cacao, via Kew.	1926.
No. 21	*P. cinnamomi* Rands, Java, Cinnamon, via Kew.	1926.

When reference is made to species not included in this list, they are marked by the letters (N.L.) i.e. not listed.

In the above list *P. palmivora* Butl. refers to the type species No. 11, which was received from India, and to those strains which have been known in the past as *P. faberi* Maubl. since it is now considered that the two are the same species. On ground of priority the name should be *P. palmivora* Butl.

No. 1 Phytophthora palmivora Butl. obtained from Black Stripe of Hevea Brasiliensis in Malacca, 1925.

This fungus was isolated by cutting away diseased bark until diseased wood was reached. Pieces of this wood were placed in test tubes, containing Maize Agar, and in some of them a pure growth was obtained in a few days. The fungus was subcultured on to various media and kept in culture for several months before it was studied in detail.

Growth on Quaker Oats Agar.

In three days a quantity of lanate aerial mycelium is produced. The mycelium is non-septate and hyaline; sporangia and chlamydospores are present in considerable numbers.

Maize Agar.

Aerial mycelium is produced in quantity after three days; it tends to be slightly shorter than on Quaker Oats Agar. Sporangia and chlamydospores are present in large numbers, the latter predominating.

Green Pea Agar.

Very little aerial mycelium is produced in three days, but the surface growth is good. Sporangia are exceedingly numerous on the surface of the medium. Chlamydospores are present in less numbers. After fourteen days there is more development of aerial mycelium, mainly confined to the lower portion of the slant.

Potato Dextrose Agar.

On this medium there is a strong growth of aerial mycelium; sporangia and chlamydospores are present in large numbers. The mycelium presents a smoother appearance than on the other media. If grown for a long time on this medium, sporangia production diminishes.

Potato Agar.

Aerial growth is good in four days, but the mycelium is short. Chlamydospores are produced in considerable numbers. The sporangia are less numerous and some of them tend to be almost spherical, differing from chlamydospores by the presence of papillae, and in having slightly thinner walls.

Potato Blocks in Roux Tubes.

After four days there is a moderate amount of lanate aerial mycelium. A large number of sporangia are produced, some long and narrow, others almost spherical, but the majority conform to type. Chlamydospores are also present in quantity. The potato cylinder becomes discolored greyish black in three weeks. (Bacteria were suspected but none were present).

Baked Slices of Young Papaya Fruit.

There is a slight growth of aerial mycelium, and large numbers of sporangia and chlamydospores are produced on the surface of the slices.

No oospores were formed on any of these media.

DESCRIPTION.

The sporangia are, in the majority of cases, pearshaped with prominent rounded papillae. They are inclined to be narrowly ovate—mean ratio of length to width being 1.66 or over,—but a few almost spherical forms can be found especially on potato media. The conidiophores are usually inserted at the base and a short portion frequently remains attached to the sporangia when they are shaken loose from the parent hyphae. A few obpyriform types with much reduced, or no papillae may be formed.

Chlamydospores are thick walled and circular and may have a large central vacuole. They may develop in clusters of three or four, on short pedicels, from circular swellings in the hyphae.

Measurements of the sporangia and chlamydospores were obtained from cultures which produced them freely and early —usually after the fifth day. The media used were Potato-dextrose, Maize, Green Pea, and Quaker Oats Agars and Potato blocks in Roux tubes. The means obtained from Quaker Oats Agar were somewhat larger than those from the other media. The figures are given in Table 1.

TABLE 1.

Details of Sporangia and Chlamydospores of No. 1 (P. palmivora Butl. from Black Stripe of Hevea (Malacca).

SPORANGIA.

Medium	Number measured.	Range in Microns.	Mean in Microns.	Range of $\frac{L}{W}$	Mean of $\frac{L}{W}$
		L x W			
Potato-Dextrose Agar	200	30-75 x 18-42	49.70 x 30.27	1.15-2.33	1.66
Maize Agar ...	100	36-78 x 23-39	50.63 x 29.49	1.25-2.33	1.71
Green Pea Agar ...	100	33-66 x 27-39	48.81 x 31.49	1.16-2.12	1.55
Quaker Oats Agar ...	100	39-75 x 24-45	56.61 x 33.09	1.23-2.50	1.72
Potato Block ..	100	36-72 x 24-39	50.25 x 30.27	1.06-2.22	1.67

CHLAMYDOSPORES.

Medium.	Number measured.	Range in Microns.	Mean in Microns.
Potato-Dextrose Agar...	100	21-45	33.06
Maize Agar ...	100	27-48	36.01
Green Pea Agar ...	100	27-48	36.75
Quaker Oats Agar ...	100	27-48	37.58
Potato Block ...	100	30-45	36.45

Inoculation Experiments.

No. 1—Six rubber seedlings, two months old, were inoculated at the collar, using mycelium and zoospores. Three seedlings were wounded and three were unwounded. The inoculations were kept moist with cotton wool for fourteen days. After three months no external signs of disease were noticed.

No. 2—Six of the same batch of seedlings were inoculated, in the same way, when they were seven months old. No external signs of disease were noticed after one month, but on splitting open the stems of the wounded seedlings a discoloration of the wood was noticed, extending about one inch up from the wound. The fungus was recovered in culture from the discolored wood.

No. 3—Leaves of two rubber seedlings were inoculated by placing a portion of Agar medium, on which the fungus was growing, on to the leaves. Some of the leaves were wounded. The plants were covered by a bell-jar to keep the atmosphere moist. The result was negative.

No. 4—The experiment was repeated, using zoospores, and the leaves were folded to hold water. After ten days there was no result.

No. 5—Three young *Hevea* pods were wounded and inoculated with the fungus. In four days there was a strong growth of mycelium on the outside of the pods and in ten days the pods were badly rotted. The fungus was recovered in culture.

No. 6—Three *Hevea* pods, unwounded, were inoculated by placing a suspension of mycelium and zoospores in the hollow formed at the stalk end. After a week the mycelium of the fungus began to appear all over the pods. Soon after, contaminations (*Gloeosporium* sp. etc.) were present, and the pods rotted away. The *Phytophthora* was recovered in culture along with numerous contaminations.

No. 7—The tapping cuts of three *Hevea* trees were inoculated by smearing a portion of Agar medium, on which

the fungus was growing, over the recently tapped bark. The inoculations were covered with moist cotton wool. A control was made by smearing Agar medium only over the tapped bark of three other trees and covering similarly. The trees were tapped daily, and, after three days, the bark of the inoculated trees was discolored with greenish black lines which had extended into the wood. The lines were also present in the cortex below the cut. The fungus was recovered in culture from the wood. The controls were unaffected after ten days.

Nos. 8, 9 & 10—Similar to above but a suspension of zoospores was used and applied to the tapping cuts on wet cotton wool. All were positive.

No. 11—Untapped virgin bark was lightly scraped over an area of one inch and inoculated with mycelium and zoospores on a piece of wet cotton wool. In twelve days a patch of diseased tissue had formed measuring 2½ x 1¼ inches. The patch was brownish pink in colour in the outer cortex, and reddish brown in the inner cortical layers and the outer layers of the wood, and was bounded by a greenish black, irregular line. The fungus was reisolated.

No. 12—The experiment was repeated on twenty trees of which ten were unwounded. All the wounded trees and four of the unwounded trees gave a positive result, the wounded trees after a few days, and the unwounded trees in from eight to ten days. The patches were very similar in all cases. Three control trees were unaffected.

No. 13—Two young papaya fruits (*Carica papaya* L.) were wounded and inoculated. There was no result until the eleventh day when a little mycelium was produced. The fruits rotted in fourteen days.

No. 14—Two plants of *Colocasia antiquorum* were inoculated on the leaves and at ground level. The result was negative even when the leaves were wounded.

No. 15—Two young Castor Oil seedlings were inoculated by wounding at soil level and pouring a suspension of zoospores over the wounds. After ten days there was

no result, so the plants were reinoculated, using mycelium and zoospores on moist cotton wool which was placed in contact with the stems of wounded and unwounded plants. The wool was kept moist for two days. The result was positive, all the plants wilting in eight to ten days. The fungus was reisolated. Controls were unaffected.

No. 18—Two plants of *Hibiscus sabdariffa L. var. altissima* (Roselle fibre) were inoculated at the collar. One was wounded and one was unwounded The result was negative.

No. 19—Two potato tubers were inoculated with the fungus. The potatoes were sterilised by soaking for three minutes in corrosive sublimate (1 : 1000) and washed in sterile water. They were then sliced and put in sterile glass jars. One of the slices in each jar was inoculated with mycelium. The result was positive, the slice being rotted in six days. A whole tuber was also inoculated and kept in a damp chamber. In five days sporangia and chlamydospores were formed in spots on the surface. The flesh of the tuber, although moderately firm in the centre, was rotted near the surface, and was full of hyphae.

No. 20—Two young tobacco plants were inoculated with the fungus at the collar, and on the leaves. The result was negative.

No. 21—Two young tomato plants were inoculated on the stem, and at soil level. The result was negative.

No. 22—Two young coconut palms were inoculated by boring a hole through the leaf bases just above the bud. A potato plug, on which the fungus was growing vigorously, was inserted and the hole was plugged. After a year there was no result. The leaves had grown and carried the fungus away from the bud. There was no rot in the leaf bases.

The results of these inoculations are summarised in Table 2 (+ ve = positive; — ve = negative).

TABLE 2.

Host plant.	Wounded or unwounded.	Point of inoculation.	Result.	No. of days after inoculation
Hevea Brasiliensis Muell. Seedlings	W	Collar	– ve	90
do do ...	W	,,	+ ve	30 Plant was not killed
Hevea Brasiliensis Muell. Leaves	W & U	midrib and epidermis	– ve	14
do do ...	,,	,,	– ve	10
Hevea Brasiliensis Muell. Fruit	W	Near the stalk end	+ ve	4–7
do do ...	U	,,	+ ve	7
Hevea Brasiliensis Muell.	W	Tapping cut	+ ve	3
do do ...	W	Virgin Bark	+ ve	12
do do ...	U	,,	+ ve	8–10
Carica papaya L. ...	W	Fruit	+ ve	11
Colocasia antiquorum Sch.	W & U	Leaves and collar	– ve	30
Riccinus communis L.	W & U	Stem at soil level	+ ve	8–10
Hibiscus sabdariffa L. var. altissima	W & U	Collar	– ve	21
Solanum tuberosum L.	W	Tuber	+ ve	5
Nicotiana tabacum L.	W	Collar	– ve	30
Lycopersicum esculentum Mill.	W	Stem and collar	– ve	30
Cocos nucifera L. ...	W	Leaf bases	– ve	365

Mixed Cultures.

In 1922, Ashby (5) published a paper on the oospores of *P. faberi Maubl.* in which he announced the finding of oospores in cultures when two strains of this fungus were grown together. In 1924, Gadd (6) published a paper on *P. faberi* Maubl. in which he distinguishes two groups of this

fungus, a rubber group and a cacao group. When a strain of the first group is grown in culture with a strain of the second group, oospores are produced, but they are not formed when members of the same group are grown together.

The Black Stripes species No. 1 is considered to be a member of the rubber group of *P. palmivora* Butl., owing to the mean ratio of the length to the width being greater than 1.60. Further, when grown in mixed culture with members of the cacao group, viz:—No. 11 *P. palmivora* Butl. (coconut, India), and No. 20 *P. palmivora* Butl. (Cacao, Trinidad), oospores are formed readily. Oospores were not obtained with No. 20 when grown in Malaya, but they developed when the mixture was made at Kew. No. 20 died out soon after its arrival in Malaya, as it was not vigorous, and this probably influenced the result. Oospores were absent in mixed cultures with members of the rubber group. Quaker Oats, Maize, and Green Pea Agars form suitable media for oospore production. On the first two, oospores turn yellow, but they remain clear for some time on Green Pea Agar. On this medium the mean diameter of 25 oospores was 23 microns.

No. 2 Phytophthora palmivora Butl. obtained from Black Stripe of Hevea in Chemor, Perak, (1928).

This fungus was isolated from the wood of a diseased tree from an area in which Black Stripe was very prevalent. In culture the growth is similar to that of No. 1; sporangia and chlamydospores being formed readily on all media used.

Quaker Oats Agar.

On this medium there is a vigorous growth of aerial mycelium, and chlamydospores are formed in two days. At first chlamydospores are found in greater abundance than sporangia which do not begin to appear in any numbers until the fourth day.

Maize, Green Pea, and Potato-dextrose Agars, and Potato Blocks in Roux tubes.

On these media the type of growth is similar to that described for species No. 1.

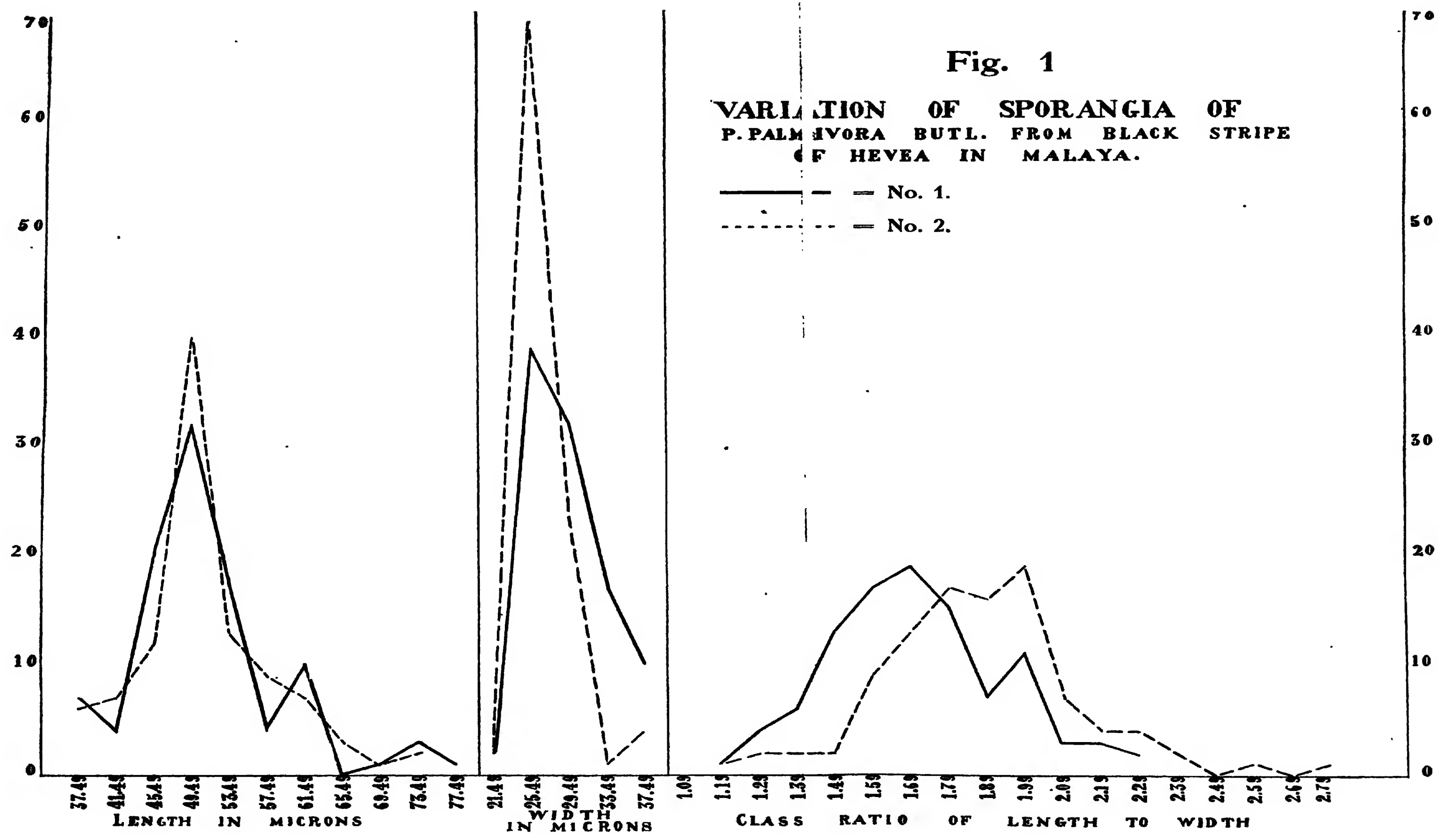


Fig. 1
VARIATION OF SPORANGIA OF
P. PALMIVORA BUTL. FROM BLACK STRIPE
OF HEVEA IN MALAYA.
No. 1.
No. 2.
0
10
20
30
40
50
60
70
37.49
41.49
45.49
49.49
53.49
57.49
61.49
65.49
69.49
73.49
77.49
LENGTH IN MICRONS
21.49
25.49
29.49
33.49
37.49
WIDTH IN MICRONS
1.09
1.19
1.29
1.39
1.49
1.59
1.69
1.79
1.89
1.99
2.09
2.19
2.29
2.39
2.49
2.59
2.69
2.79
CLASS RATIO OF LENGTH TO WIDTH

The fungus is of the same species as No. 1, but the sporangia have more elongated papillae and are not so wide on the average. Otherwise its morphology is similar, and, when inoculated into *Hevea*, Castor, Potato and Papaya, it gives a similar effect. One curious feature of the fungus is that a number of sporangia, on germinating, produce a short germ tube on which a chlamydospore is formed. When the sporangium becomes free, if placed in water, the chlamydospore remains attached and the two float about together. (Plate I).

Measurements of the sporangia have been obtained on Maize Agar. Details are given in Table 3.

TABLE 3.

Sporangia of No. 2 (P. palmivora Butl.), obtained from Black Stripe of Hevea Chemor, Perak, F.M.S.

Medium	Number measured	Range in microns.	Mean in microns	Range of $\frac{L}{W}$	Mean of $\frac{L}{W}$
Maize Agar	100	36-75 x 21-36	50.97 x 26.93	1.21-2.79	1.87

This strain is very typical of the rubber group of *P. palmivora* Butl. and in mixed culture it behaves similarly to No. 1, forming oospores when mixed, on Green Pea Agar, with No. 11. The mean diameter of these oospores was 24.16 microns.

The variation in the length etc. of the sporangia of No. 1, and of No. 2, on Maize Agar, is illustrated graphically in Fig. 1.

No. 3 Phytophthora sp. obtained from Black Stripe of Hevea, in Negri Sembilan, F.M.S.

This species was isolated from a bark specimen received from Seremban.

Quaker Oats Agar.

On this medium a strong growth of mycelium is formed. The growth is dense and fills the test tube with a white,

compact mass of mycelium in seven to eight days. No sporangia have been found, either on the aerial mycelium, or in the medium, until after twelve days. As the culture ages a moderate number are formed.

Maize Agar.

On this medium the growth is very similar to that on Quaker Oats Agar.

Green Pea Agar.

Mycelial growth is good but not so dense as on the above media. The sporangia, which are produced in fair numbers after eight days, are of two types—broadly ovate with papillae and spherical with no papillae.

Potato dextrose Agar.

Mycelial growth is good. At first it is confined to the surface of the agar along which it spreads in a dense fan of "parallel" hyphae. Aerial hyphae are formed behind the advancing edge of growth and form a compact smooth mass. The sporangia which develop after eight days are small.

One of the best methods of obtaining large numbers of sporangia is to grow the fungus in water to which a seed of *Vigna catjong* is added. A green pod is opened and a young bean extracted with a sterile needle. This is placed in a little sterile water in a sterile petri dish, and mycelium from a young culture is placed on the bean. After twenty four hours a good growth of mycelium is obtained in the water surrounding the bean, and in three days thousands of sporangia are produced. These sporangia tend to be larger and fatter than those produced in agar culture. A variety of shapes are formed but the majority are broadly ovate, with rounded papillae. Some appear almost circular and have papillae which are only seen by careful focussing. Some are circular and have no papillae. They are slightly smaller than the circular, papillate sporangia, but are not quite as thick walled as chlamydospores of the "palmivora" type. Loose sporangia may or may not have a portion of the sporangiophore attached. Species No. 6, and No. 7 (*P. meadii* McRae) form similar large numbers and types of sporangia and "sphaeroconidia" if grown in this water medium.

Potato Block in Roux Tubes.

The fungus grows slowly but in ten days produces a little aerial mycelium. A few sporangia are formed about the fourteenth day, both types being present. The round bodies (27—34 microns) resemble chlamydospores, but they are not definitely thick walled.

Malt Extract Agar. (Leonian's formula).

After six days there is a slight growth of aerial mycelium. A few sporangia are produced about the fourteenth day.

Glucose Meat Extract Agar.

The growth is slow and mostly submerged but a little powdery surface mycelium is formed. Both types of sporangia are present in seven days but they are very few in number.

Measurements of the sporangia have been obtained from Green pea Agar, Water and bean, and Quaker Oats Agar and are given in Table 4. The circular forms, without papillae have not been included.

TABLE 4.

Sporangia of No. 3 Phytophthora sp. from Black Stripe of Hevea, Negri Sembilan, F. M. S.

Medium	Number measured	Range in microns.	Mean in microns	Range of $\frac{L}{W}$	Mean of $\frac{L}{W}$
Green Pea Agar	100	26-51 x 20-39	36.50 x 28.17	1.08-1.85	1.34
Water & Bean ..	100	33-69 x 27-42	47.01 x 33.69	1.08-2.30	1.44
Quaker Oats Agar	100	30-66 x 21-39	41.67 x 30.29	1.08-2.44	1.37

INOCULATION EXPERIMENTS.

No. 1—Untapped *Hevea* bark was wounded, and inoculated in the same way as described for species No. 1. The result was positive after 10 days; a patch 2″ x 3½″ had formed in the bark, while the wood was penetrated to a depth of ½ an inch.

No. 2—Untapped and unwounded *Hevea* bark was inoculated. The result was positive after ten days. The patch formed was smaller than in No. 1 experiment, but the infection had reached into the wood and had penetrated it slightly. The fungus was reisolated.

No. 3—A tobacco plant, one foot in height, was wounded at soil level and inoculated with a suspension of zoospores and mycelium. In five days the plant wilted. The roots were found to be in an unhealthy condition but the stem tissues were not affected. Attempts to reisolate the fungus were not successful. The control also became infected and died, so the experiment was inconclusive. The experiment was repeated on two healthy plants and the result was negative.

No. 4—The tapping cut of a rubber tree was inoculated with the fungus. Black Stripe developed in a few days.

No. 5—A pod of *Hevea* was slightly wounded and inoculated with mycelium and zoospores and kept moist. In six days the pod was rotted and covered with mycelium.

No. 6—Three unwounded pods of *Hevea* were inoculated with mycelium and zoospores. The pods, which were attached to a cut branch standing in water, were covered with a bell-jar containing moist cotton wool. The inoculum was placed in a drop of water around the stalks of the pods. The water did not evaporate for two days but there was no sign of rot. After seven days the pods were still green and fresh.

No 7—The above pods were pricked with a needle until latex flowed, and a fresh inoculation was made near the wounds. In two days a watery discoloration appeared near the wounds, and, four days later, the pods were covered with mycelium and rotted.

No. 8—Two plants of Roselle (*Hibiscus sabdariffa* L.) were inoculated at soil level; both were slightly wounded. The result was positive after eight days.

No. 9—Two Castor Oil plants were wounded and inoculated at soil level. The plants wilted in six days and the fungus was recovered from the stem.

No. 10—Two potato tubers were inoculated. A wet rot appeared after six days, but no external mycelium was formed. Controls remained normal.

No. 11—Two young *Hevea* plants were wounded slightly, and inoculated at the collar, and on the stem three inches from soil level. After a month there was no sign of disease externally, but, on cutting open the bark under the inoculations, it was found that the bark and wood were discolored with blackish green lines which extended about two inches up and down the stem. The collars of the seedlings were not quite girdled by the fungus nor was the stem girdled higher up. The wood tissue was full of hyphae which had not quite penetrated to the pith. The leaves looked quite healthy when compared with the controls. The fungus was reisolated from the wood.

Mixed Cultures.

Oospores have not been formed in pure culture, but, if the fungus is grown in mixed culture with No. 8 (from *Hibiscus sabdariffa* L.), oospores, with amphigynous antheridia, are formed after ten days. No. 8 does not form oospores in pure culture, but it is a species distinct from No. 3, and bears a close resemblance to No. 13 (*P. parasitica* Dast.) Its taxonomy will be discussed later. Oospores also are formed in abundance when No. 3 is grown in mixed culture with No. 12 (*P. arecae* Coleman); they appear in four or five days. *P. meadii* McRae and *P. arecae* Coleman, are considered by Ashby (7) to be very similar and possibly strains of one species. They have not formed oospores in pure culture in Malaya, but if grown together in mixed culture, oospores, with amphigynous anteridia, are freely formed in five days on Green Pea Agar. They range from 17—27 microns, the mean of 50 being 24.32 microns. The oospores formed when No. 3 is mixed with *P. arecae* range from 21—28.6 microns, the mean being 24.70 microns. Oospores have not been formed, after a month, when No. 3 was grown, in mixed culture, with No. 7 (*P. meadii* McRae) on Green Pea Agar.

This suggests a relationship between No. 7 (*P. meadii* McRae) and No. 3, which is further confirmed by the fact that oospores are formed after ten days on Green Pea Agar, if No. 7 (*P meadii* McRae) is grown in mixed culture with

No. 8 (from *H. sabdariffa* L.) They range on this medium from 18.5—27 microns, the mean of 50 being 23.04 microns. The oospores formed in the mixture of No. 3 with No. 8 range from 19—28 microns the mean being 23.80 microns.

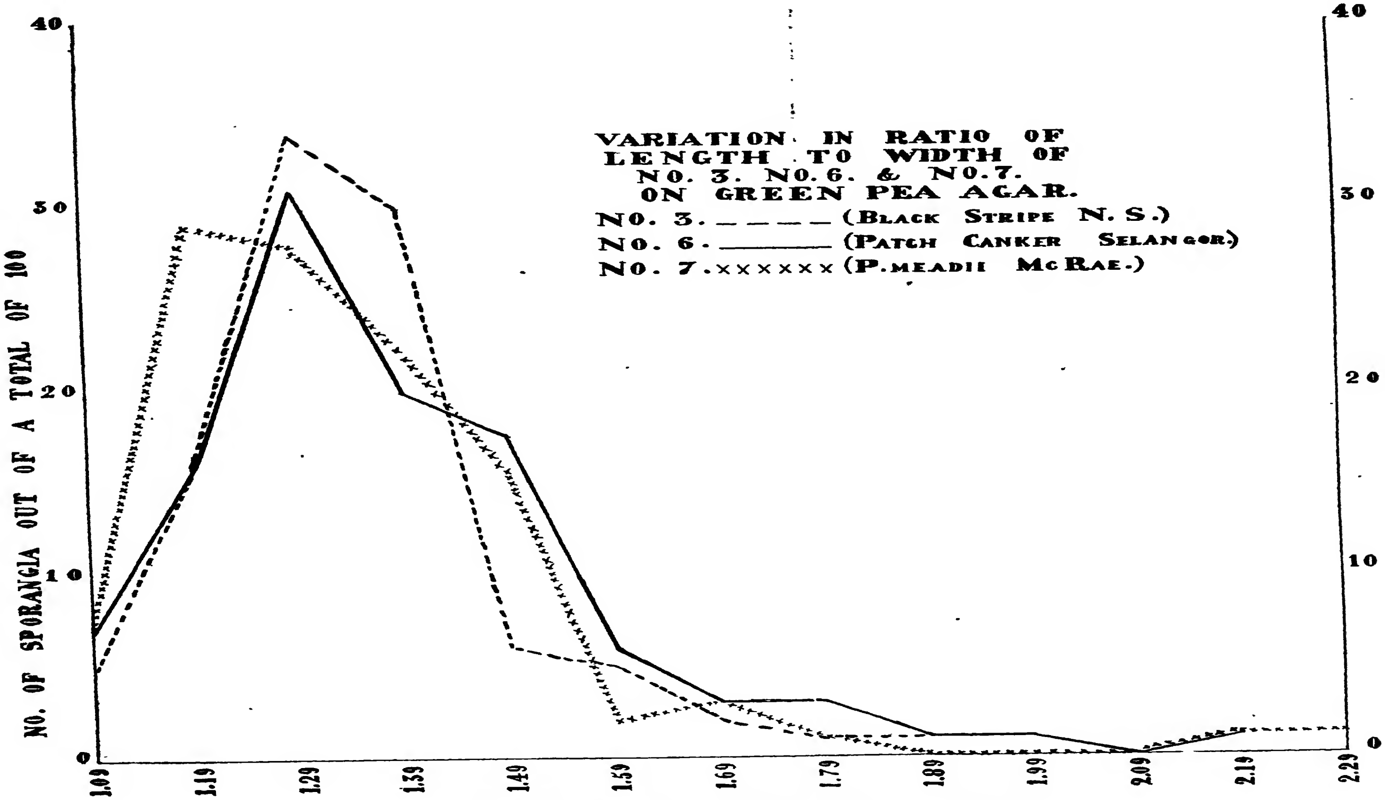
The sporangia of No. 7 (*P. meadii* McRae) are slightly larger than those of No. 3, but the length to width ratio is the same (1.32 and 1.34 on Green Pea Agar) (Fig. 2). The sporangia of No. 12 (*P. arecae* Coleman) are nearer in size to those of No. 3, but the length to width ratio is slightly smaller (1.28 and 1.34).

The mycelium and type of growth on various media, is very similar for all three strains.

If No. 7 (*P. meadii* McRae) and No. 12 (*P. arecae* Coleman) are considered to be strains of one species, then No. 3 can be included in this species, under the name—for the present—of *P. meadii* McRae, since it behaves similarly to that species in mixed culture, and has a similar morphology. The oospores formed when No. 3 and No. 7 are each grown with No. 8 in mixed culture, are not formed until the tenth day, while in the mixtures with No. 12 (*P. arecae* Coleman) they appear in abundance after the fourth day. *P. meadii* McRae is known occasionally to form oospores in pure culture in India, and in the mixtures with a distinct species (No. 8), oospores are also formed; but it is uncertain to which of the two species they belong, since there is no very significant difference in size between these oospores and those formed in the *meadii*, and *arecae* mixtures, and mixtures of No. 8 with strains of No. 13, and No. 16 (*P. parasitica* Dast), and Nos. 1 and 2 (*P. palmivora* Butl.-rubber group). (See page 87).

No. 4 Phytophthora sp. obtained from Black Stripe of Hevea, in Malacca, 1928.

The fungus was isolated from the wood of a tree affected with Black Stripe. The affection was slight, only two thin stripes being evident. The tree was growing in a native holding and was apparently the only one attacked by this disease. Almost all the other trees in tapping were badly affected with Mouldy Rot, but in no case were the two diseases found on one tree. Three days after the culture was prepared, large numbers of oospores, with amphigynous antheridia, were


VARIATION IN RATIO OF LENGTH TO WIDTH OF NO. 3. NO. 6. & NO. 7. ON GREEN PEA AGAR.
NO. 3. - - - - - (BLACK STRIPE N. S.)
NO. 6. ———— (PATCH CANKER SELANGOR.)
NO. 7. ×××××× (P. MEADII McRAE.)
NO. OF SPORANGIA OUT OF A TOTAL OF 100
0
10
20
30
40
1.09
1.19
1.29
1.39
1.49
1.59
1.69
1.79
1.89
1.99
2.09
2.19
2.29
CLASS RATIO OF LENGTH TO WIDTH
FIG. 2.

formed on the surface of the medium. A few sporangia had formed, and these were present in large numbers on the following day. It was soon evident that the fungus was identical with No 5 which had been isolated from *Hevea* pods in the previous year.

No.5 PHYTOPHTHORA SP. OBTAINED FROM POD ROT OF HEVEA, IN SELANGOR, 1927.

In December 1927, some pods of Hevea which were rather late in forming, fell from a tree while still green. The pods were discolored with dark, watery, green patches, some near the stalk end and others at the opposite end. Cultures were prepared and freed from impurities in the usual way.

THE FUNGUS IN CULTURE.

Quaker Oats Agar.

In two days there is a good surface growth of mycelium, but aerial mycelium is not produced until after fourteen days, and even then it is very scanty. The first cultures from the pods produced oospores in large numbers, but only a few sporangia until the seventh day. In subsequent transfers however, sporangia developed early. They are irregular in shape. No definite chlamydospores are formed, but some of the spore forms are circular. The sporangiophore is frequently inserted laterally.

Green Pea Agar.

No aerial mycelium is formed on this medium, but the surface growth is good. Sporangia are formed in two days on the surface and in the medium; they are produced in abundance and are very irregular in shape. Some are broadly ovate; some are circular with no papillae; others are long and narrow with prominent papillae, obpyriform, or curved. Oospores appear after the fourth day in large numbers, both on the surface and in the medium.

Potato Agar.

The fungus does not grow well on this medium; there is no aerial mycelium formed and the mycelium in the medium

is scanty, but the hyphae are larger than usual. Oospores are formed, but they are very few in number. A large number or oogonia with antheridia develop, but the majority disintegrate without forming oospores. No sporangia are formed up to three weeks.

Potato dextrose Agar.

On this medium there is sometimes a slight aerial growth which is rather tufted. The medium becomes cloudy and wrinkled (bacteria were proved to be absent). Sporangia are sparingly produced at first, and large numbers of oospores develop in the medium.

Maize Agar.

Scanty aerial mycelium may be formed on this medium, but the surface growth is good. Sporangia and oospores are formed in large numbers. The majority of sporangia are of the more narrowly ovate type, and many of them have the sporangiophore at the side.

Potato Blocks in Roux Tubes.

There is no growth on this medium.

Malt Extract Agar. (Leonian's formula).

Growth is entirely submerged. Large numbers of sporangia are produced after two days. They are very mishappen, some are curved and distorted, others are long and narrow and rounded at both ends, having no papillae. A few are roughly circular, thick-walled, types with no papillae. No oospores are formed up to the fifth day, but large numbers are present by the fourteenth day. Many are coloured yellow brown.

Water and Bean.

In two days a fair quantity of mycelium is present. Sporangia and oospores are formed on the fourth day. The sporangia are more regular in shape than those on solid media some are broadly ovate, and some are almost spherical. A number of the sporangia look like chlamydospores but they are rather thinner walled than these bodies, and many, which appear to be circular at first, shew papillae when focussed

more carefully. The elongated forms are absent, or few in number, in the earlier stages of growth. Measurements of sporangia and oospores are given in Table 5.

TABLE 5.

Sporangia and oospores of No. 5 Phytophthora sp. from Hevea pods, in Selangor, F.M.S.

SPORANGIA.

Medium	Number measured	Range in microns	Mean in microns	Range of $\frac{L}{W}$	Mean of $\frac{L}{W}$
Potato-Dextrose Agar ...	100	27-63 x 20.5-42	44.31 x 27 89	1.12-2.48	1.56
Maize Agar	100	30-60 x 21-39	45.85 x 27.42	1.09-2.85	1.73
Quaker Oats Agar	100	30-66 x 21-48	45.06 x 31.13	1.05-2.57	1.47
Green Pea Agar	100	36-60 x 21-39	46.74 x 32.07	1.15-2.14	1.46
Water & Bean ...	100	36-44 x 27-36	39.13 x 33.13	1.08-1.33	1.17

OOGONIA & OOSPORES.

Medium	Number measured	Range of oogonia in microns	Range of oospores in microns	Mean of oogonia in microns	Mean of oospores in microns
Quaker Oats Agar	100	17-30	15-24	25.25	20.43
Green Pea Agar ...	50	21-28	18-24	24.76	20.17
Maize Agar ...	50	—	18-26	—	22.00
Potato-Dextrose Agar	50	21-32	17-26.8	27.74	23.25

Inoculation Experiments.

No. 1—The tapping cuts of two *Hevea* trees were inoculated with mycelium and zoospores. The trees were tapped daily, and, in four days, shewed signs of Black Stripe. The fungus spread downwards into the wood below the cut, and, near the cut, penetrated into the wood to a depth of half an inch.

No. 2—A little Agar medium containing spores and mycelium of the fungus was smeared over the bark of a

tree in tapping just above the cut. In five days definite Black Stripe symptoms were present.

No. 3—The leaves and petioles of a growing rubber seedling were inoculated, by placing a little agar medium, containing mycelium and zoospores, on the leaves and at the junction of the petiole and the stem. The leaves and stem were pushed into a flask containing wet cotton wool. The inoculated leaves fell in two days but no rot was noticed.

No. 4—Young and old leaves of a rubber seedling were inoculated as above, but the leaves were folded to retain a small drop of water. Zoospores were placed in the water drops which did not evaporate for two days. After six days a watery spot, less than half an inch in diameter, developed on some of the young leaves. Hyphae were present in the spots, but attempts to re-isolate the fungus were unsuccessful, probably owing to the large numbers of protozoa and bacteria which developed in the cultures. The older leaves were not affected.

No. 5—The above experiment was repeated but only one leaf became diseased.

No. 6—Two *Hevea* seedlings were wounded and inoculated at soil level. The result was similar to that of experiment No. 11 with fungus No. 3. The seedlings were not killed after a month, but the fungus was present in the stem and was reisolated at the end of this period.

No. 7—Six *Hevea* pods were sterilised with corrosive sublimate, washed in sterile water, put into sterile, moist jars, and inoculated at the stalk end. Three pods were wounded, two were unwounded, and one wounded pod was kept as a control. In six days the wounded pods were covered with mycelium, and a little mycelium was present on the unwounded pods, which were discolored near the stalk. On the eighth day these stalks became covered with a mixture of *Gloeosporium* sp. and *Phytophthora*. The control developed *Gloeosporium* on the tenth day (probably introduced by mites). Oospores were found in the mycelium on the pods; they were yellowish in colour.

No. 8—Castor Oil seedlings were killed by the fungus in four days.

No. 9—Untapped *Hevea* bark was wounded and inoculated with mycelium and zoospores. In fourteen days a patch had formed in the bark and wood. Oospores were found in the tissues of the wood.

No. 10—Potato tubers were sterilised in corrosive sublimate, wounded and inoculated, and kept in sterile jars. The result was negative.

No. 11—A tobacco plant was wounded and inoculated on the stem above soil level. The result was negative.

No. 12—An immature papaya fruit was wounded and inoculated and kept under a bell jar. The fruit remained healthy for twenty days after which it slowly decayed. The control gave a similar result, and, since the original fungus was not recovered from the inoculation, the result must be considered negative.

Description.

Mycelium.—The mycelium is non-septate when young, but in cultures of a month old, septa are frequently formed. The hyphae are but slightly branched and are rarely wider than 5 microns, the average being about 4.6 microns. Aerial mycelium is absent or very scanty. A little may be formed on Maize Agar after fourteen days but sometimes none is formed.

Sporangia.—These are of several types and vary greatly in shape on Agar media. The papillae are sometimes pointed and sometimes round. The sporangiophore is very frequently inserted at the side, especially in the case of curved sporangia. In a few instances there is a swelling in the sporangiophore some distance beneath the sporangium and immediately above this swelling there may be a septum. Spherical. papillate sporangia, sometimes with thicker walls than normal, are common, and in some cases the papillae are not very evident. These types look like chlamydospores, but if the cover slip is moved carefully, some of them turn over and papillae can then be seen. No true chlamydospores, either intercalar or terminal, have been found.

Oospores.—These bodies are produced early and in large numbers, on all the Agar media, and in water culture. The oogonium is characteristically "funnel" shaped and is surrounded at the base by the antheridium through which it appears to have penetrated. Paragynous antheridia have not been seen. The oospores frequently almost fill the oogonial cavity, and have fairly thick, smooth walls (about 3 microns wide). They are not definitely coloured on Green Pea Agar, but in one month old cultures on Maize Agar they are sometimes brownish, and on Malt-Extract Agar the majority are slightly yellowish. The contents are granular and oily; a vacuole is frequently present.

Taxonomy.—The fungus has not been previously reported from Malaya, and it differs from No. 7 (*P. meadii* McRae) which causes *Hevea* pod-rot in South India. The absence of aerial mycelium, the shape of the oogonium, the smaller and more numerous oospores, and the larger length to width ratio of the sporangia of the Malayan species, are sufficiently significant characters to separate it from No. 7 (*P. meadii* McRae). The absence of chlamydospores, and the non-production of aerial mycelium, separates the species from Nos. 13 and 16 (*P. parasitica* Dast.), and Nos. 9 and 10 (*P. colocasiae* Rac.), Nos. 1, 2, 11, 18, 19 and 20 (*P. palmivora* Butl.), and Dastur's species from *Hevea* in Burma (8). Significant differences also exist between the Malayan fungus and No. 21 (*P. cinnamomi* Rands), No. 12 (*P. arecae* Coleman), *P. erythroseptica* Pethyb. (N.L.), *P. infestans* Mont. de Bary (N.L.), and *P. Jatrophae* Jens. (N.L.).

The exclusively amphigynous antheridia and other characters separate it from *P. cactorum* Cohn and Lebert. (N.L.), *P. fagi* Hartig (N.L.), *P. syringae* Kleb. (N.L.), *P. Paeoniae* Cooper & Porter (N.L.), *P. pini* Leonian (N.L.).

Rosenbaum (9) established a *Phaseoli* group in his classification of the *Phytophthorae*, and the Malayan species would be included in this group from the fact that the antheridium is at the base of the oogonium. The members of this *Phaseoli* group are *P. phaseoli* (N.L.), *P. erythroseptica* (N.L.), No. 12 (*P. arecae*), No. 13 (*P. parasitica*), and *P. infestans* (N.L.). Of these species *P. phaseoli* is perhaps nearest to the local species, but the sporangia are stated to be small, (27.87 x 19.05 microns) and fluffy aerial mycelium is formed on Oat, Maize, and Bean Agars. On Malt Extract Agar *P. phaseoli*,

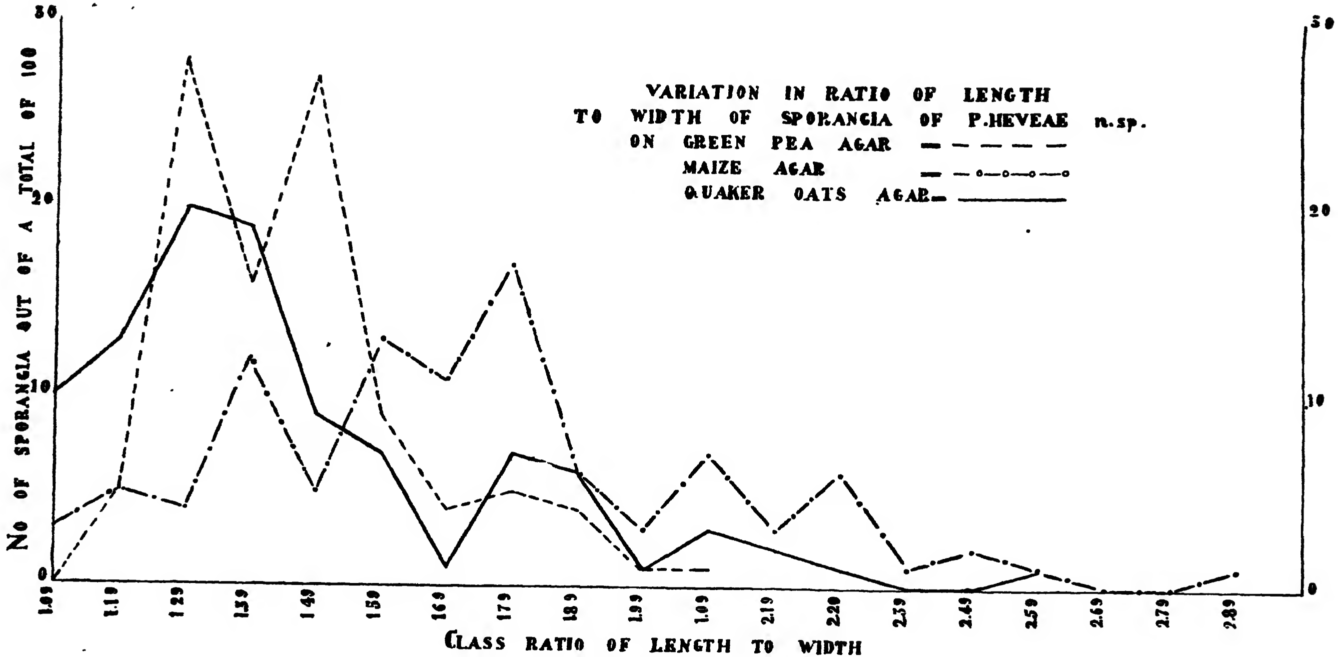

VARIATION IN RATIO OF LENGTH
TO WIDTH OF SPORANGIA OF P.HEVEAE n.sp.
ON GREEN PEA AGAR
MAIZE AGAR
QUAKER OATS AGAR
No OF SPORANGIA OUT OF A TOTAL OF 100
30
20
10
0
1.09
1.19
1.29
1.39
1.49
1.59
1.69
1.79
1.89
1.99
2.09
2.19
2.29
2.39
2.49
2.59
2.69
2.79
2.89
CLASS RATIO OF LENGTH TO WIDTH

FIG. 4.

according to Leonian (10), forms but few sporangia, moderate aerial mycelium, and does not form a colony. The *Hevea* species forms a colony, 35 mm. in diameter, in two days at 25°—30°C., and produces large numbers of sporangia and no aerial hyphae.

These differences are considered to be sufficiently significant to separate the *Hevea* species from *P. phaseoli* Thaxter, and it is proposed to regard it as a new species, and to name it *P. heveae* (Thompson). The species has been examined by the Mycologist (S. F. Ashby) at the Imperial Bureau of Mycology who states "It has not been possible to refer this to any known species". The description is as follows:—

Phytophthora heveae n.sp.—Mycelium submerged on Agar media, and not formed on Potato Blocks, non-septate when young, 2-7 microns in width. Sporangia present on most Agar media, and in water culture to which a seed of *Vigna catjang* is added, but absent or few in number on Potato Agar; somewhat irregular in shape, varying from spherical to narrowly ovate; sporangiophore frequently inserted laterally. Range of sporangia 27-66 x 20.5-48 microns, average of 400 = 45.49 x 29.62 microns. Mean ratio of length to width = 1.55. Oogonia and oospores freely formed on Potato-dextrose and other Agar media and also in water. Oogonia broadly funnel shaped with amphigynous antheridia. Oospores round, smooth, and thick walled, not always coloured distinctly. Range of 200 oogonia = 17-32 microns, mean = 25.91 microns, range of 250 oospores = 15-26.8 microns, mean = 21.46 microns. Parasitic in Malaya on bark and fruit of *Hevea brasiliensis* (H.B.K.) Muell. Arg. Para Rubber.

No 6 Phytophthora sp. isolated from Patch Canker of Hevea brasiliensis in Selangor F.M.S. (1926).

The fungus was obtained from the bark of a ten year old rubber tree which had never been tapped. The tree was one of three in a group and all were diseased, having one or more patches of discolored bark about four feet from the ground. The patches were not larger than roughly 2-3 inches in diameter and the disease had penetrated into the wood. The fungus was isolated from the inner cortex which was greyish red in colour.

Growth in Culture.

Quaker Oats Agar.

After five days there is a copious growth of somewhat lanate aerial mycelium. Sporangia are sparingly produced until after the ninth day when the number increases.

Maize Agar.

The growth is similar to that on Quaker Oats Agar.

Green Pea Agar.

A fair amount of aerial mycelium is present in three days. Sporangia may be present on the fourth day and are numerous after twelve days.

Potato dextrose Agar.

After five days there is copious aerial mycelium present. Sporangia are present after the seventh day. Growth on this medium is similar to that of No. 3 on the same medium.

Potato Agar.

Growth is mostly in the medium, aerial hyphae being scanty. No sporangia up to the fourteenth day.

Potato Blocks in Roux Tubes.

The fungus grows slowly on this medium, but in time a quantity of aerial mycelium is formed. Sporangia are not formed until after a month.

Baked Slices of Young Papaya Fruit.

There is a strong growth of aerial mycelium, but no sporangia until after fourteen days and then only a few develop.

Water and Bean.

In two days the water contains a good growth of mycelium in groups, probably formed by zoospores liberated from

sporangia in the inoculum. In three days large numbers of sporangia are present.

Malt Extract Agar.—(Leonian's formula). Growth on this medium is similar to that of No. 3 and No. 7 (*P. meadii* McRae), on the same medium. Mycelium is sparsely aerial in six days, and sporangia few in number on the fourteenth day. The number increases after a month but they are not numerous.

Description.

Mycelium.—This is produced copiously on most media. The aerial hyphae are little branched and range from 1.5—6 microns in diameter. The submerged mycelium is more branched and the contents more granular. The hyphae range from 2—9 microns in diameter.

Sporangia.—These are regular in shape, curved types being rare. The majority are inclined to be somewhat broadly ovate, (l/w ratio less than 1.50) and have prominent papillae. The sporangiophore is usually at the base, rarely lateral, and part of it may remain attached to the free sporangia. No definite chlamydospores have been found, but circular spore forms are developed. Some of these have papillae which are often difficult to see, but in some no papillae can be distinguished. These types were, at first considered to be chlamydospores, but they are not so thick walled as the chlamydospores of No. 1 (*P. palmivora* Butl.) or No. 12 (*P. parasitica* Dast.) They range from 27-42 microns in diameter, and are probably similar to those forms found in species No. 3, No. 5 and No. 7, and to the reduced sporangia which were described in the species obtained from Black Stripe in 1916 (2). A few elongated, narrowly ovate, sporangia, are also developed, especially on Maize Agar, and in old water and bean cultures. In the latter medium sporangia are very numerous; at first they are broadly ovate and resemble those of No. 3 and No. 7 (*P. meadii* McRae), but later on distorted forms sometimes appear which are very long and narrow. Circular forms with no papillae are fairly numerous.

Zoospores.—The sporangia when placed in water germinate directly, or may produce zoospores. The large sporangia do not often produce zoospores, but the smaller ones do so, soon after they are placed in water. No difficulty has been

experienced in obtaining zoospores, from sporangia which have developed in cultures grown purely on artificial media for long periods. They are produced in the usual manner, escaping one by one or in groups, from the opening in the papillae of the sporangia.

Oospores.—No oospores have been formed in pure culture on any medium.

Measurements of sporangia have been obtained from cultures soon after the appearance of the sporangia. The circular forms without papillae have not been included, as they are regarded as being reduced sporangia.

TABLE 6.

Sporangia of No. 6 Phytophthora sp. isolated from Patch Canker of Hevea, in Selangor, F.M.S. 1926.

Medium	Number measured	Range in microns.	Mean in microns	Range of $\frac{L}{W}$	Mean of $\frac{L}{W}$
Potato-Dextrose Agar ..	200	27-69x21-45	41.57x30.64	1.10-1.82	1.36
Maize Agar	100	33-66x24-39	42.08x29.60	1.11-2.50	1.45*
" " ..	100	27-63x21-42	43.08x30.96	1.10-2.33	1.39
Quaker Oats Agar	100	33-66x27-45	46.98x33.67	1.13-2.22	1.39
Green Pea Agar	200	27-72x21-45	43.85x27.38	1.02-2.20	1.36
Water & Bean ...	50	36-66x24.42	46.00x32 15	1.18-1.80	1.44

*fresh isolation.

Inoculation Experiments.

No. 1—Two Hevea seedlings, two months old were wounded and inoculated, with mycelium and zoospores (a) at the collar, (b) on the stem three inches from the ground, (c) on the leaves and petioles. All were kept moist with cotton wool.

Some of the inoculated leaves fell after a week, but there was no discoloration. The tissues of the stem

and collar were discolored similarly to those of the seedlings inoculated with species No. 1, No. 3 and No. 5, but the plants were not killed. The fungus was recovered in culture from the wood.

No. 2—Untapped bark of six *Hevea* trees was lightly scraped and inoculated. After eighteen days a patch 3½" x 2" had formed and the wood was penetrated to the depth of about ½ an inch. The fungus was reisolated.

No. 3—Unwounded bark of *Hevea* was inoculated by smearing a portion of a culture over the bark and keeping it moist. In five days rubber was found on the outside of the bark, under the inoculation, and, on opening up the bark, a patch 3" x 2" was found which involved the wood to a depth of quarter of an inch. The patch was similar to those found in nature. The fungus was recovered from the wood.

No. 4—Tapped bark of *Hevea* was inoculated and Black Stripe developed in four days. The stripes were somewhat broader than those obtained with fungus No. 1.

No. 5—*Hevea* pods were flamed, put into sterile jars, wounded slightly, and inoculated by placing a little mycelium and zoospores in water near the stalk end. In seven days the pods were rotted and covered with mycelium.

No. 6—Similar to Experiment No. 5 but the pods were unwounded. In eight days the pods were beginning to rot near the point of inoculation and after ten days mycelium appeared all over the pods. The fungus was recovered in culture along with *Gloeosporium* sp. The controls remained healthy for twelve days after which they became covered with *Gloeosporium* sp. and rotted.

No. 7—Potato tubers were wounded, inoculated with mycelium, and kept in sterile jars. In six days the tubers rotted and mycelium was present in the tissues. No aerial hyphae were formed. The controls were unaffected.

No. 8—Two young papaya fruits were wounded and inoculated. There was no evident results for twelve days, after which mycelium appeared and the fruits rotted.

No. 9—Two plants of *Colocasia antiquorum* Sch. were inoculated The result was negative.

No. 10—Tomato and Tobacco plants of varying ages were wounded and inoculated, but the result was negative.

No. 11—Three young Castor Oil Plants, unwounded, were killed by the fungus in five days.

The results of the inoculations are summarised in Table 7. (+ ve = positive; — ve = negative.)

TABLE 7.

Host Plant	Wounded or Unwounded.	Point of inoculation.	Result.	Number of days.
Hevea Brasiliensis Muell. Seedlings	W	Collar and stem	+ ve	30
Hevea Brasiliensis Muell. Leaves	W	Leaf and petiole	- ve	30
Hevea Brasiliensis Muell. Bark	W	Trunk	+ ve	18
Hevea Brasiliensis Muell. Bark	U	do	+ ve	5
Hevea Brasiliensis Muell. Bark	W	Tapping cut	+ ve	4
Hevea Brasiliensis Muell. Fruit	W	Stalk end	+ ve	7
Hevea Brasiliensis Muell. Fruit	U	do	+ ve	8
Solanum Tuberosum L. ...	W	Tubers	+ ve	6
Carica papaya L. ...	W	Fruit	+ ve	12
Colocasia antiquorum Sch.	W	Leaves & collar	- ve	30
Nicotiana tabacum L.	W	Stem	- ve	30
Lycopersicum esculentum Mill.	W	do	- ve	30
Riccinus communis L.	U	do	+ ve	5

Mixed cultures and Taxonomy

No. 6 has been grown in mixed culture with Nos 1, 2, 3, 7, 8, 11, 12, 13, 14, 16, 18, 19 and 20, but oospores have not been formed. It is therefore difficult to assign No. 6 to any species. The absence of typical chlamydospores, and differences in growth on various media, separate it from Nos. 1, 2, 11, 18, 19 and 20 (*P. palmivora* Butl.) and No. 13 (*P. parasitica* Dast). In water culture and on Malt extract Agar and Potato-dextrose Agar, there is a resemblance to *P. meadii* McRae (No. 7 and No. 3.) On Green Pea Agar the aerial growth of Nos. 6, 7 and 3 is similar, and many of the spore forms are of the same type and have approximately the same ratio of length to width (Fig. 2). Nos. 6, 7 and 3 are alike in developing circular spore forms without papillae, and with thinner walls than the chlamydospores of *P. palmivora* Butl. No. 7 and No. 3 behave identically in mixed culture and are considered to be of the same species, but No. 6 has given no results in mixed culture. Morphologically, it comes nearer to Nos. 3 & 7 (*P. meadii* McRae) or No. 12 (*P. arecae* Coleman), when grown in culture in this country, than to any of the other species or strains examined, but, until oospores have been obtained, it cannot be given a specific name.

No. 8 Phytophthora sp. isolated from a disease of Hibiscus sabdariffa L. var. altissima (Roselle Fibre).

During the slump in rubber in 1922-1924 some interest was taken locally in the cultivation of Roselle fibre. A disease soon appeared, which, under certain conditions, was capable of doing considerable damage.

Symptoms.

When the plants are about two feet high or more, the stems of some of them become discolored, at soil level, by a dark brown, almost black, band, which extends slowly up the stems to a height of from three inches to more than a foot. The leaves and tips of these plants droop, but death does not take place rapidly. Sometimes the epidermis of affected plants splits, after rain, near the border of the healthy and diseased tissue, and gum exudes. The epidermis is somewhat sunken in the discoloured area on which

the cell walls form a network. The disease progresses more rapidly in the cortex than in the wood vessels, and the cortex at soil level appears to be the first part attacked. Secondary organisms e.g. *Fusarium* spp. and bacteria invade the tissues soon after they are attacked, and render isolation of the causal organism a matter of some difficulty. Some of the roots are affected near the collar, but others do not decay until the plant dies.

The tissues in the cortex of diseased plants are full of mycelium. Some of the hyphae are large and nonseptate and are mainly intercellular, and accompanying these are smaller septate hyphae. Isolations from the advancing edge of the disease usually yield a species of *Phytophthora* mixed with a species of *Fusarium*. It was found difficult to separate these two fungi, but it was eventually accomplished by inoculating rubber bark with a portion of an impure culture. The *Phytophthora* penetrated into the rubber wood and was obtained pure when reisolated.

Pure cultures of the *Fusarium* sp. failed to attack Roselle plants, and, since the *Phytophthora* sp. can reproduce the disease, it was considered to be the causal agent.

Growth in Culture.

Mycelium.—The fungus grows well on agar media, producing copious aerial mycelium on Quaker Oats Maize and Green Pea Agars. On Potato-Dextrose Agar, in Petri dish culture, the mycelium is lanate and not compact, and the growth is somewhat zoned. The hyphae vary in width from 2—10 microns, the majority being about 6 microns wide. The aerial hyphae are only slightly branched.

Sporangia.—These are formed sparingly and late on Quaker Oats and Maize Agar, but on Green Pea Agar they are present in good numbers after fourteen days. They are broadly ovate (l/w ratio = 1.25) and have prominent papillae. Zoospores are freely produced when sporangia are placed in water. In water and bean culture or in plain water large numbers of sporangia are produced in three days. They are slightly larger than those formed on Agar media and some are almost circular, but the length to width ratio is practically the same (1.23.)

Chlamydospores.—On Quaker Oats and Maize Agars brownish chlamydospores are formed in abundance after fourteen days. They are more numerous than sporangia on these media, but less numerous on Green Pea Agar. They are terminal or intercalar and range from 21-45 microns in diameter, the mean being in the neighbourhood of 30 microns on Agar media, and 36 microns in water culture.

Oospores.—No oospores have been formed in pure culture on any medium.

Measurements of sporangia and chlamydospores have been obtained from cultures on Green Pea and Quaker Oats Agar, and from water culture. These are given in Table 8. Only 30 sporangia were measured on Quaker Oats Agar as only a few had formed.

TABLE 8.

Sporangia and Chlamydospores of No. 8 Phytophthora sp. isolated from Hibiscus Sabdariffa L. from Selangor F.M.S. (1928).

SPORANGIA.

Medium.	Number measured.	Range in microns.	Mean in microns.	Range of $\frac{L}{W}$	Mean of $\frac{L}{W}$
Green Pea Agar	100	30-54 x 24-45	43.57 x 35.65	1.06-1.75	1.25
Quaker Oats Agar	30	30-64 x 24-39	39.09 x 31.62	1.07-1.77	1.24
Water & Bean ..	100	30-63 x 24-51	45.05 x 36.33	1.06-1.91	1.23

CHLAMYDOSPORES.

Medium.	Number measured.	Range in microns.	Mean in microns.
Green Pea Agar ...	100	25-45	32.64
Quaker Oats Agar ..	100	21-45	30.93
Water and Bean ...	100	25.5-45	36.69

Inoculation Experiments.

No. 1—Six Roselle plants were wounded and inoculated, at soil level, with mycelium and zoospores from a culture of the *Phytophthora*. In twelve days the typical symptoms of the disease were present; the fungus had travelled seven inches up the stem. The fungus was reisolated.

No. 2—Six Roselle plants were inoculated with the *Fusarium* sp. also isolated from diseased tissues. The result was negative.

No. 3—A Roselle plant was inoculated on the stem one foot from soil level. In six days the disease was present on the stem, which had a brownish black band on four inches of the surface and in the cortex.

No. 4—Untapped Hevea bark, lightly wounded, was inoculated. Patch Canker developed in ten days, the wood being slightly penetrated.

No. 5—The tapping cuts of two rubber trees were inoculated. Black Stripe was present in four days.

No. 6—Two Hevea fruits were wounded and inoculated with the fungus. In ten days mycelium appeared on the pods which were rotted.

No. 7—Potato tubers were inoculated with the fungus. In six days the tubers rotted.

No. 8—A young papaya fruit was inoculated but remained healthy for over a month.

Mixed Cultures and Taxonomy.

Since oospores have not been found in pure cultures, various mixed cultures were made and oospores were obtained in certain cases. The antheridia were always amphigynous. The results are given in Table 9. Green Pea, Maize and Quaker Oats Agar were used but Green Pea Agar was found to be most satisfactory. (+ ve = oospores present; —ve = oospores absent).

TABLE 9.

Oospores in mixed cultures of No. 8 with other species of Phytophthora.

Mixture.	Result	Number of Days.	Mean Diameter in microns.
No. 8 & No. 1 *P. Palmivora* rubber group ...	+ ve	6	22.67
No. 8 & No. 2 ,, ,, ...	+ ve	5	23.01
No. 8 & No. 18 ,, ,, ...	+ ve	6	22.69
No. 8 & No. 11 ,, cacao group	– ve	30	—
No. 8 & No. 3 *P. meadii* (Malaya)	+ ve	10	23.80
No. 8 & No. 7 *P. meadii* (India) ..	+ ve	10	23.04
No. 8 & No. 12 *P. arecae* ,, ...	– ve	30	—
No. 8 & No. 13 *P. parasitica* (India) ...	+ ve	4	21.16
No. 8 & No. 16 *P. nicotianae* (Sumatra) ...	+ ve	4	23.67
No. 8 & No. 6 *Phytophthora* sp. *Hevea* F. M. S. ...	– ve	30	—

From the above table it will be seen that oospores are formed when No. 8 is grown in mixed culture with members of the rubber group of *P. palmivora* Butl. (Nos. 1, 2 and 18), but not when grown with a member of the cacao group (No 11.) This indicates that the *Hibiscus* species may possibly be a member of the cacao group of *P. palmivora* Butl. Ashby,* who also obtained oospores only in the mixture with the rubber group, considers that the *Hibiscus* species is an atypical member of the cacao group of *P. palmivora* Butl. The oospores are formed in five or six days while those formed in the mixtures with No. 7 (*P. meadii*) from India and No. 3 from Malaya do not appear for ten days. Furthermore No. 8 differs from *P. meadii* in forming chlamydospores in abundance, a feature also in common with

* Private communication.

P. palmivora. Ashby has observed that some of the sporangia of No. 8 in water culture separate with a short pedicel attached in the same manner as in *P. palmivora* Butl. Consequently if Gadd's (6) theory of heterothallism in *P. palmivora* (*faberi*) is accepted, the thallus of No. 8 can be regarded as being complementary to that of a member of the rubber group of *P. palmivora* and therefore No. 8 can be assigned to the cacao group of that species. The oospores formed in mixtures of No 8 with the local and Indian strains of *P. meadii* McRae may be regarded as belonging to *P. meadii* or as hybrids in which *P. meadii*, known to be homothallic, supplies possibly the male elements and No. 8 the female elements. Gadd (11) has suggested that this is probably what occurs when large oospores appear in mixtures of small oospore forming strains of *P. parasitica* Dast and *P. palmivora* Butl.

Ashby (7) has merged *P. parasitica* Dast. and *P. nicotianae* B. de H. into one species—*P. parasitica* Dast. The writer has obtained from India *P. parasitica* Dast (No. 13), isolated from *Riccinus communis* L., and *P. nicotianae* B. de H. (No. 16), isolated from tobacco in Sumatra. These two species are identical in growth and neither of them have formed oospores in pure culture in Malaya. No. 8 is also morphologically similar to these two strains and in pure culture the three are identical in growth, and behave similarly if inoculated into *Hevea* bark (causing Patch Canker and Black Stripe), and into Roselle (causing wilt).

The similarity in the spores of the three species on Green Pea Agar is shown in Table 10.

TABLE 10.

Details of the spore forms of No. 13, No. 16 and No. 8 on Green Pea Agar.

Species.	Mean of Sporangia in microns.	Mean of Chlamydospores in microns.	Mean ratio of $\frac{L}{W}$
No. 13	45.89 x 35.97	36.19	1.26
No. 16	46.77 x 36.29	35.67	1.28
No. 8	43.57 x 35.65	32.64	1.25

The figures are practically identical in Nos. 13 and 16 and those of No. 8 are only slightly smaller.

Consequently on morphological grounds, No. 8 can be considered to be of the same species as No. 13 and No. 16 viz. *P. parasitica Dast. Sect. macrospora.* Furthermore, as shown in Table 9, oospores are formed when No. 8 is grown in mixed culture with No. 13 and with No. 16, and they are formed in four days. This suggests that No. 8 is heterothallic, and that its thallus is complementary to that of No. 13 and of No 16 and that these are also heterothallic. But No. 13 is known to be homothallic, since it is known to form oospores in pure culture in India and in England, and No. 16 (which came from the same area in Sumatra as the species in which Ashby (7) found oospores, in pure culture, in England) may also be homothallic. Up to the present No. 8 has not formed oospores in pure culture in England, but it is possible that it may do so eventually, in which case the question would be settled, and No. 8 could not be considered to be a member of the cacao group of *P. palmivora* Butl., and the oospores formed in the mixture with that species could be looked on as hybrids. The larger oospores obtained by Ashby (5) and Lester Smith (12), in mixtures of *P. palmivora* and *P. parasitica*, were obtained from oospore forming strains of *P. parasitica* and thus were probably hybrids as Gadd suggests (11). No. 13 and No. 16 have not formed oospores in Malaya, and recently, the writer mixed them in culture with both groups of *P. palmivora*, and with each other. The result was as follows:

No. 13 & No. 1	*P. palmivora* rubber group	=	— ve	30 days.
No. 16 & No. 1	,, ,, ,,		— ve	30 ,,
No. 13 & No. 11	,, cacao ,,		+ ve	4 ,,
No. 16 & No. 11	,, ,, ,,		+ ve	4 ,,
No. 13 & No. 16	Two strains of *P. parasitica*		— ve	30 ,,

This shews that No. 13 and No. 16 both behave similarly in forming oospores when mixed with a member of the cacao group of *P. palmivora* (No. 11). None were formed in mixtures with the rubber group, neither were any formed when No. 13 and No. 16 were mixed together. This indicates that No. 13 and No. 16 are of the same biologic strain, and that they can be regarded as atypical members of the rubber

group. of *P. palmivora* Butl. Since No. 8 can be included in the cacao group of *P. palmivora,* then the three fungi, Nos. 8, 13 and 16, can be referred to one species viz. *P. palmivora* Butl., but they can also be referred to *P. parasitica* Dast., since they are typical of the species (No. 13) which came from India as the type of the species.

The oospores formed in the mixtures of Nos. 13 and 16 with the cacao group of *P. palmivora* may be hybrids, and the result comparable to that obtained by Ashby and Lester Smith, but in that case one would expect to find oospores in the mixtures with the rubber group, but this has not happened. It would appear then, that Nos. 13 and 16, in culture Malaya, are heterothallic, and that the oospores formed are the result of a fertilisation between antheridia and oogonia from two heterothallic strains, one (No. 11) typical of *P. palmivora* Butl. cacao group and the other (No. 13 or No. 16) atypical of this species and in the rubber group. The biologic difference between Nos. 13 and 16 and No. 8 is further exemplified in mixed cultures with No. 3 and No. 7 (*P. meadii* McRae). Oospores are formed in mixtures of No. 8 with Nos. 3 and 7, but are absent when Nos. 13 and 16 are each mixed with Nos. 3 and 7.

The behaviour of *Phytophthora* spp. when grown in culture in a country different to that of origin is known to be erratic, and spore forms which are absent in one country may be present in another. What the factors are which influence this behaviour is uncertain. Oospore formation, in pure cultures of homothallic strains, is also erratic. The conclusions which can, at present, be drawn from the result of mixed cultures of the three *Phytophthorae* No. 8, No. 13 and No. 16, are:—

(1) They are members of one species, and are heterothallic in culture in Malaya.

(2) No. 8 is morphologically similar to Nos. 13 and 16, but biologically dissimilar.

(3) Nos. 13 and 16 are of the same biologic strain.

(4) Nos. 13 and 16 can be regarded as atypical members of the rubber group of *P. palmivora* Butl., and No. 8 as an atypical member of the cacao group of that species.

(5) *P. parasitica* Dast. may develop homothallic and heterothallic strains, and the latter can be regarded as being atypical members of *P. palmivora* Butl.

On account of the similarity between No. 8 and Nos. 13 and 16 (*P. parasitica* Dast.), it is considered that No. 8 should be referred to this species, especially since Nos. 13 and 16 behave similarly in forming oospores, in mixed culture, with *P. palmivora* Butl. If No. 8 is considered to be atypical of *P. palmivora* Butl., then Nos. 13 and 16 should also be placed in this species; but if Nos. 13 and 16 are really strains of *P. parasitica* Dast., and therefore homothallic, this cannot be done until further information is available.

No. 9 Phytophthora colocasiae Rac. isolated from a wilt of Sireh (Piper Betle L.) at Pekan, Pahang, F.M.S..

A note on the fungus causing this disease was published in 1926 (4). Since that date the disease has not been reported from any area, and it was therefore impossible to determine whether more than one species of *Phytophthora* was present on this host in Malaya. The fungus has recently died out in culture, although attempts were made to invigorate it by inoculation on to Sireh and other hosts. The writer was enabled to study the fungus for a short period at the Imperial Bureau of Mycology, Kew, in the summer of 1926. Cultures which were grown at the Bureau grew vigorously and developed oospores freely, thus enabling the Mycologist (Mr. S. F. Ashby) to identify the fungus as *P. colocasiae* Rac. Oospores were not formed when the fungus was grown in this country, and they did not develop after the fungus was brought back from Kew and sub-cultured. On the other hand a type species of *P. colocasiae* Rac. from America, which was also brought back to Malaya, continued to produce oospores in this country.

The strain from Sireh grows well on most agar media, aerial mycelium being formed copiously. Sporangia and chlamydospores are developed fairly early and are characteristic of *P. colocasiae* Rac. Some of the sporangia are broadly ovate and others are very narrowly ovate, separating with a long slender pedicel. Zoospores are produced in the usual manner, but are formed principally by the smaller sporangia. They are large, ranging from 12—16 microns in diameter when they

round off. Active zoospores measure 12-14 x 8.5-10.5 microns. Oospores with amphigynous antheridia, are formed, in England, on Quaker Oats Agar, Maize Agar and on Bean Agar, in five days. They are coloured brownish yellow when mature, and range from 19.5—31.5 microns, those on Quaker Oats Agar being somewhat larger than the others. Chalmydospores are formed on agar media; they may be terminal or intercalar and are usually spherical with a thick wall. The diameter ranges from 18—33 microns, the mean of 100 being 24.45 microns.

TABLE 11.

Measurements of sporangia, chlamydospores and oospores of P. colocasiae Rac. from Piper Betle L. in Malaya.

SPORANGIA.

Medium	Number measured	Range in microns	Mean in microns	Range of L/W	Mean of L/W
Maize Agar .	200	27-70 x 18-39	41.99 x 27.25	1.18-2.36	1.68
Green Pea Agar	150		40.36 x 28.43		
Quaker Oats Agar ...	100	27-72 x 18-39	43.57 x 25.89	1.27-2.40	1 70
Rubber Pods ...	50		39.62 x 24.35		
Arecanuts ..	60		39.42 x 24.35		

CHLAMYDOSPORES.

Medium	Number measured.	Range in microns.	Mean in microns.
Maize Agar	100	18-33	24.45

OOSPORES.*

Bean Agar ...	50	19.7-27.4	23.1
Maize Agar ...	32	19.5-26.3	22.1
Quaker Oats Agar ...	24	19.0-31.5	25.6

* Obtained from the Imperial Bureau of Mycology.

The fungus is not a vigorous parasite, except under conditions which favour it *e.g.* badly drained soil and abundant moisture. Inoculation experiments were only successful on Sireh plants when the inoculation was kept very moist. After growing in culture for some time the fungus tends to lose its virulence, and the sporangia nearly always germinate directly without forming zoospores. When first isolated the fungus was capable of causing Patch Canker of *Hevea*, if the inoculation was kept very moist for fourteen days. The patches of diseased tissue were mainly confined to the cortex. Green Areca nuts were also susceptible to attack, but, although the fungus produced sporangia on the surface of the fruit, the mycelium did not penetrate very deeply into the tissues. On rubber pods the fungus grew well and rotted the pods in six days. Plants of *Colocasia antiquorum* Sch. were inoculated, but were not attacked by the fungus. The inoculations were done, however, after the fungus had been in culture for two years, and had ceased to give positive results on Sireh and *Hevea*, so the result is not conclusive.

CONTROL MEASURES.

The disease has not reappeared on the affected plots which were dug up and exposed to the sun during dry weather, and which, later, were better drained during the wet periods.

Since oospores have not been found, either in the tissues of the diseased Sireh plants or in culture in Malaya, it is probable that this treatment would be sufficient, in itself, to keep the disease in check. Should it not do so, soil disinfectants such as formalin, or Uspulun, could be applied at first, but the principal measures are adequate drainage and reduction of atmospheric moisture, by keeping down weeds and reducing shade, in wet weather.

Remarks.

Up to the present, three species of *Phytophthora* have been isolated from naturally occurring cases of Black Stripe disease of *H. brasiliensis* Muell., and inoculation experiments have shown that all three can reproduce the typical symptoms of the disease. The three species are as follows:—

(a) *P. palmivora* Butl. rubber group, (isolated frequently).

(b) *P. meadii* McRae, (isolated once).

(c) *P. heveae* Thompson, (isolated once).

These species are not all confined to Black Stripe disease; *P. palmivora* Butl. has also been obtained from naturally occurring Patch Canker, and *P. heveae* Thompson, from naturally occurring pod-rot. The species are not confined to any one locality e.g. *P. palmivora* Butl. occurs in Malacca and Perak South, and Perak North, while *P. heveae* Thompson occurs in Selangor and in Malacca.

In the case of Patch Canker of *H. brasiliensis* Muell. two species of *Phytophthora*, and one species of *Pythium*,* have been found responsible. The species are:—

(a) *P. palmivora* Butl. rubber group.

(b) No. 6 (undetermined).

(c) *Pythium* sp. (probably *P. complectens* Braun.)

In the case of Pod-rot disease of *H. brasiliensis* Muell., one species of *Phytophthora*—*P. heveae* Thompson—and the *Pythium* sp. have been found to cause the disease (1).

As far as *Phytophthora* is concerned, it cannot be concluded, however, that the species mentioned above are the only ones which cause bark and fruit disease of *H. brasiliensis* in Malaya. Inoculation experiments have shown that other species can cause the diseases mentioned, and it is highly probable that some of them will later be found naturally attacking the bark and fruit of the rubber tree.

No. 8 from *Hibiscus sabdariffa* L., No. 13 from *Riccinus communis* L. and No. 16 from Tobacco are strains of the same species and all can attack the bark of *Hevea*, giving

* The bark disease caused by this fungus has only been found in one area—Perak South. It may take the form of Collar Patch Canker. The fungus has been isolated from Patch Canker on two occasions, and from pod-rot on one occasion. It will be described in a later publication.

effects similar to the Black Stripe and Patch Canker diseases, caused by those species naturally associated with these diseases. The same result was obtained when No. 14 (from *Piper Betle* L. Pusa, India), and Nos. 18 and 19 (*P. palmivora* Butl. from coconut, Jamaica, and cotton, St. Vincent), were inoculated into Hevea. No. 11 *P. palmivora* Butl. Cacao Group) can also attack rubber bark in similar fashion. This fungus, which was isolated from coconut bud-rot in India, is a typical member of the cacao group of *P. palmivora* Butl., but no typical member of this group has, as yet, been isolated from any host in Malaya. Bud-rot of the coconut palm, caused by *Phytophthora*, has not been found in Malaya, but whether this is due to the fact that typical members of the cacao group of *P. palmivora* Butl. are not present, is a matter for conjecture. Inoculations on coconut palms with the local species of *P. palmivora* Butl. from Hevea have given negative results, while an inoculation with No. 11 was successful. These experiments require repetition as the weather was very dry for some months after the inoculations were made. No. 18 (Ashby's strain from Coconuts in Jamaica) is a member of the rubber group of *P. palmivora* Butl. This strain also failed to produce bud-rot when inoculated into coconut palms in this country, but the result is inconclusive, owing to the dry weather conditions which prevailed at the time. It is hoped to experiment further with inoculations on coconuts and other palms, when occasion permits, in order to obtain more information as to the degree of virulence of the members of the cacao and rubber group of *P. palmivora* Butl. on these hosts. Coconut plantations and rubber plantations are often located together, and in most native rubber holdings coconut palms can be found. Yet, in areas where Black Stripe disease is prevalent, adjoining coconut palms remain free from Bud-rot. Cacao is rarely grown in Malaya and *Phytophthora* pod-rot of this plant has not been encountered. *P. palmivora* (*faberi*) cacao group causes pod-rot of cacao in Ceylon, and Gadd (11) has shown that this strain will produce bud rot of wounded coconut palms almost as readily as the Ceylon coconut strain, which is also a member of the cacao group of *P. palmivora* Butl. Neither of these two strains, nor the strain from *Hevea* (rubber group), appear to be very virulent to coconuts in Ceylon, since field observations indicate that *Phytophthora* bud-rot of coconuts is not serious, even in mixed areas of coconuts, cacao and *Hevea*, when the cacao and *Hevea* trees are badly infected with canker or pod-rot.

Climatic conditions in Malaya undoubtedly influence the rate of spread and the severity of the *Phytophthora* diseases. On the western side of the peninsula, the rainfall, during the wetter months, falls mostly in the afternoons and nights, and is preceded or followed by bright sunny mornings Damp misty mornings are comparatively rare and consequently the spores of *Phytophthora*, which may have alighted on the leaves and fruit of the rubber trees, are soon dried out and killed. This is considered to be one of the main reasons why Malayan rubber plantations have remained so free from the diseases known as secondary leaf fall and pod-rot caused by *Phytophthora*, especially since No. 3 (*P. meadii* McRae), and Nos. 1 and 2 (*P. palmivora* Butl.), known to cause these diseases in India and Ceylon, have been found in Malava. The behaviour of *P. heveae* Thompson will be watched with interest, now that it has been proved that Pod-rot of *Hevea* does occur in Malaya. Black Stripe disease which affects the tapping cut is fairly prevalent, because the overhead shade of the leaves prevents the sun from having access to the atmosphere near the trunk, and humidity remains high. The effect of this is well marked in native small holdings where overcrowding of the trees, and the presence of undergrowth, leads to increased humidity and severe attacks of bark diseases.

The disease of *Hibiscus sabdariffa* L. is rarely evident until the plants have grown sufficiently, and produced enough leaves, to give overhead shade to the soil. When this occurs the disease appears, in wet weather, in areas where the drainage is inadequate.

Black Stripe and Patch Canker diseases of the rubber tree have been dealt with by investigators in other tropical countries. In Java Rutgers (13) showed that *P palmivora* (*faberi*), obtained from Cacao and Nutmeg, could cause Black Stripe and Patch Canker of *Hevea*, but he does not mention that he isolated a *Phytophthora* from naturally occuring cases of the diseases on Hevea. Had this been attempted he would not have confused Brown Bast disease with Patch Canker, and much later confusion would have been avoided. His statement that *P. nicotianae* B. de H. would not attack the rubber tree, is interesting in view of the result obtained by the writer with No. 16 *P. nicotianae* (*parasitica*) from tobacco in Sumatra, which can attack *Hevea* bark. On the other hand, No. 17 (*P. nicotianae* (*parasitica*)), which was

isolated by Rutgers in Java and received by the writer from Kew, does not attack *Hevea* in Malaya and is probably the same species as the one used by Rutgers. This indicates that the species from Java is probably not of the same strain as the species from Sumatra. The latter can attack *Hevea* and may later be found to be a cause of Black Stripe or Patch Canker of Hevea in Sumatra. The same suggestion can be made in the case of No. 8 from Malaya and No. 13, No. 14 and No. 11 from India, since these species, on inoculation, can causes Black Stripe and Patch Canker of *Hevea* in Malaya, and may also be found to be natural responsible agents for these diseases in their respective countries. In Ceylon, *P. palmivora* (*faberi*) is recorded as the cause of Black Stripe, Patch Canker, and Pod-rot of *Hevea*, the evidence being obtained, in the case of Black Stripe and Patch Caker, as a result of inoculations with a strain of this species obtained from Cacao. The matter has been settled in the case of Pod-rot of *Hevea* by actual isolation of *P. palmivora* (*faberi*) from diseased pods (6) but there is no definite information as to whether more than one species of *Phytophthora* is normally responsible for this or the other two diseases.

Seedling Inoculations.

In the preceding pages mention is made of inoculations of *Hevea* seedlings with some of the local *Phytophthora* spp. Although the stems and collars of the seedlings were wounded before inoculation, none of the seedlings were killed. Fungus hyphae were present in the wood tissues of the inoculated seedlings and were proved to be viable, a month after the inoculation, by successful reisolations. According to Sharples et al (2), the *Phytophthora* sp. isolated from Black Stripe in 1916, was capable of killing *Hevea* seedlings, but only if they were wounded. In view of this result, it is necessary to investigate the matter further, since the possibility of attack on wounded stocks used for bud-grafting must not be overlooked.

There are no reports of a naturally occurring *Phytophthora* disease of *Hevea* seedlings from any of the rubber producing countries, and if seedlings are susceptible to attack it is strange that no such disease has occurred. The explanation is probably to be found in the fact that seedlings in nurseries are not much exposed to accidental injury, or excessive humidity, and consequently a possible *Phytophthora* attack is averted.

Summary.

1. Eight local isolations of *Phytophthora* have been studied. Of these, six were obtained from bark or fruit diseases of *Hevea brasiliensis* Muell., one was isolated from a disease of Roselle fibre plants (*Hibiscus sabdariffa L. var altissima*), and one was isolated from a disease of Sireh (*Piper Betle L.*)

2. Three species of *Phytophthora* are directly responsible for Black Stripe disease of *Hevea* in Malaya, i.e.

(a) *P. palmivora* Butl. rubber group.

(b) *P. meadii* McRae.

(c) *P. heveae* Thompson,—a new species.

Two species of *Phytophthora* and one species of *Pythium* are direct causes of Patch Canker i.e.

(a) *P. palmivora* Butl. rubber group.

(b) An unnamed species of *Phytophthora*, listed as No. 6.

(c) *Pythium* sp, (*P. complectens* Braun?).

In the case of pod-rot of *Hevea*, *P. heveae* Thompson and the *Pythium* sp. *P. complectens* Braun?) are direct causes of the disease.

3. Certain other *Phytophthorae*, from host plants other than *Hevea*, are capable of causing Black Stripe and Patch Canker of *Hevea* if artificially inoculated into the bark. These species are:

(a) No. 11 (*P. palmivora* Butl. cacao group), isolated in India, from bud-rot of the coconut palm.

(b) No. 14, (*Phytophthora* sp.) isolated, in India, from a disease of *Piper Betle* L.

(c) No. 18, (*Phytophthora palmivora* Butl. rubber group), isolated, in Jamaica, from the coconut palm.

(d) No. 19, (*P. palmivora* Butl. rubber group), isolated, in St. Vincent from a disease of cotton.

(e) No. 13, (*P. parasitica* Dast.), isolated, in India, from a disease of Castor Oil Plants.

(f) No. 16, (*P. nicotianae* B. de H. (syn *P. parasitica* Dast.)), isolated, in Sumatra, from a disease of tobacco.

(g) No. 8, (*P. parasitica* Dast.), isolated, in Malaya, from a disease of Roselle fibre plants.

4. A disease of Roselle fibre (*H. sabdariffa* L. *var altissima*) is described. The disease may be serious if drainage is inadequate. The causal organism is No. 8 (*P. parasitica* Dast.). Evidence, obtained from mixed cultures, shows that if this strain is regarded as an atypical member of the cacao group of *P. palmivora* Butl., No. 13 (*P. parasitica* Dast. India), and No. 16 (*P. nicotianae* (*parasitica*) Sumatra), when grown in culture in Malaya, may be regarded as atypical members of the rubber group of *P. palmivora* Butl.

5. The fungus which caused the disease of Sireh (*Piper Betle* L.) in Pekan, Pahang, in 1924 has been identified as *P. colocasiae* Rac. Oospores were formed when the fungus was grown in culture in England in 1926, but they have not been formed in Malaya.

6. Records have been made of the growth and morphology of the different species and strains of *Phytophthora* received, or isolated in Malaya, by the writer. These will be of value in studying any future isolations.

The writer is indebted to Professor S. F. Ashby of the Imperial Bureau of Mycology, for various cultures received, and for much useful advice in identification of the species. Thanks are also due to Dr. McRae, of the Agricultural Research Institute, Pusa, India, and to the Director of the Deli Proefstation, Medan, Sumatra, who kindly forwarded cultures.

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Note.—Since going to press a disease of Sireh (*Piper Betle* L.) has occurred in Selangor F.M.S. A *Phytophthora* has been isolated, but not yet examined in detail. It appears to be similar to the species obtained in 1924 from Sireh in Pahang i.e. *P. colocasiae* Rac. When inoculated into lightly wounded *Hevea* bark, it caused Patch Canker: the wood was deeply penetrated in five days. It also caused Black Stripe when placed on the tapping cut

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PLATE I.

A Sporangia and chlamydospores of No. 1 (*P. palmivora* Butl. rubber group), from Black Stripe of *Hevea*, in Malacca, S.S.

B. Sporangia and chlamydospores of No. 2 (*P. palmivora* Butl. rubber group), from Black Stripe of *Hevea*, in Perak, F.M.S.

C. Formation of oospore in mixed culture of No. 1 (*P. palmivora* Butl. rubber group) with No. 11 (*P. palmivora* Butl. cacao group).

D. *P. heveae* Thompson, showing sporangia and oospore formation.

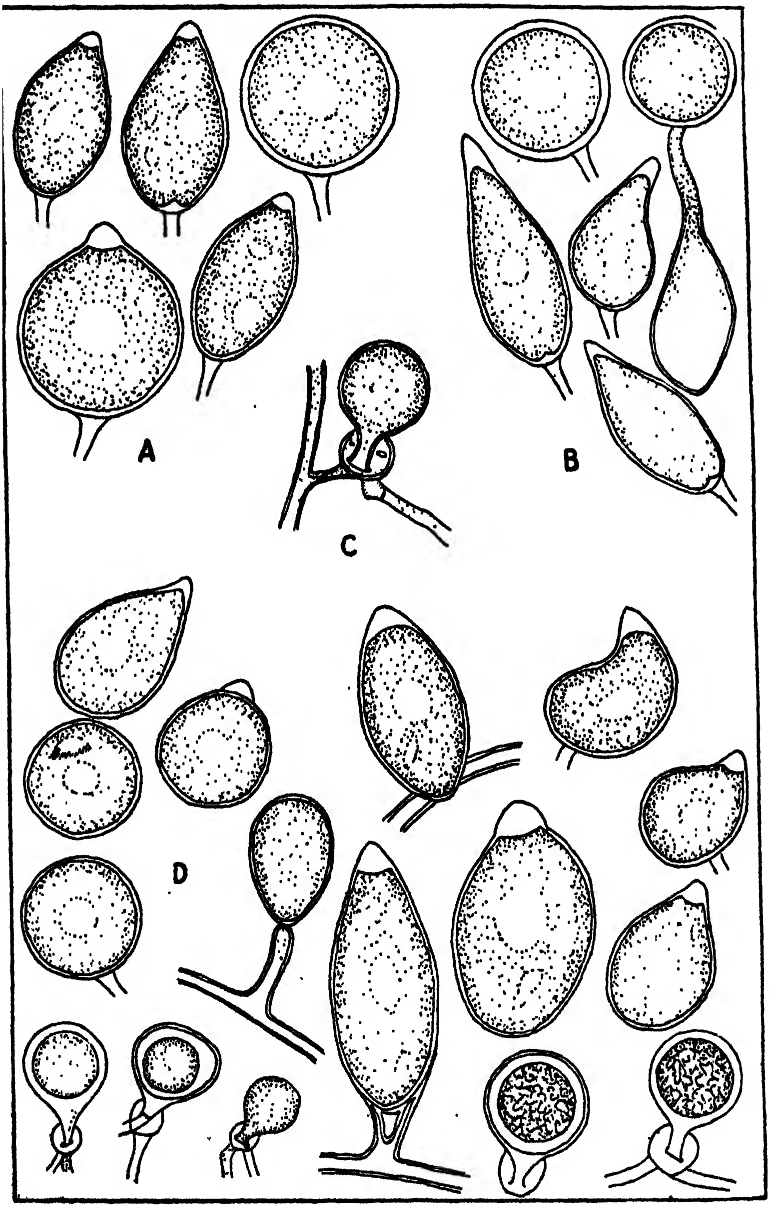

A
B
C
D

PLATE II.

D. Sporangia of No. 3 (*P. meadii*, Malaya), from Black Stripe of *Hevea* in Negri Sembilan, F.M.S.

E. Sporangia of No. 7 (*P. meadii*, India).

F. Sporangia of No. 6 (*Phytophthora* sp.), from Patch Canker of *Hevea*, in Selangor, F.M.S.

G. Sporangia of No. 12 (*P. arecae* Coleman India).

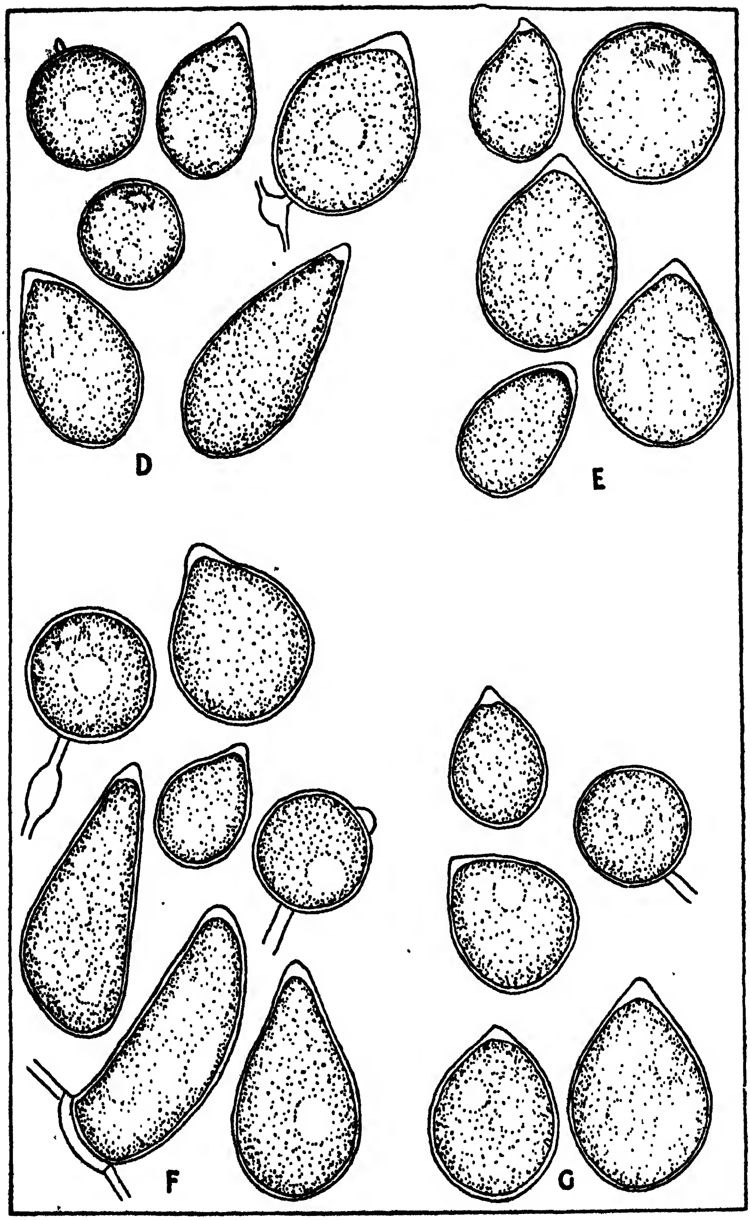
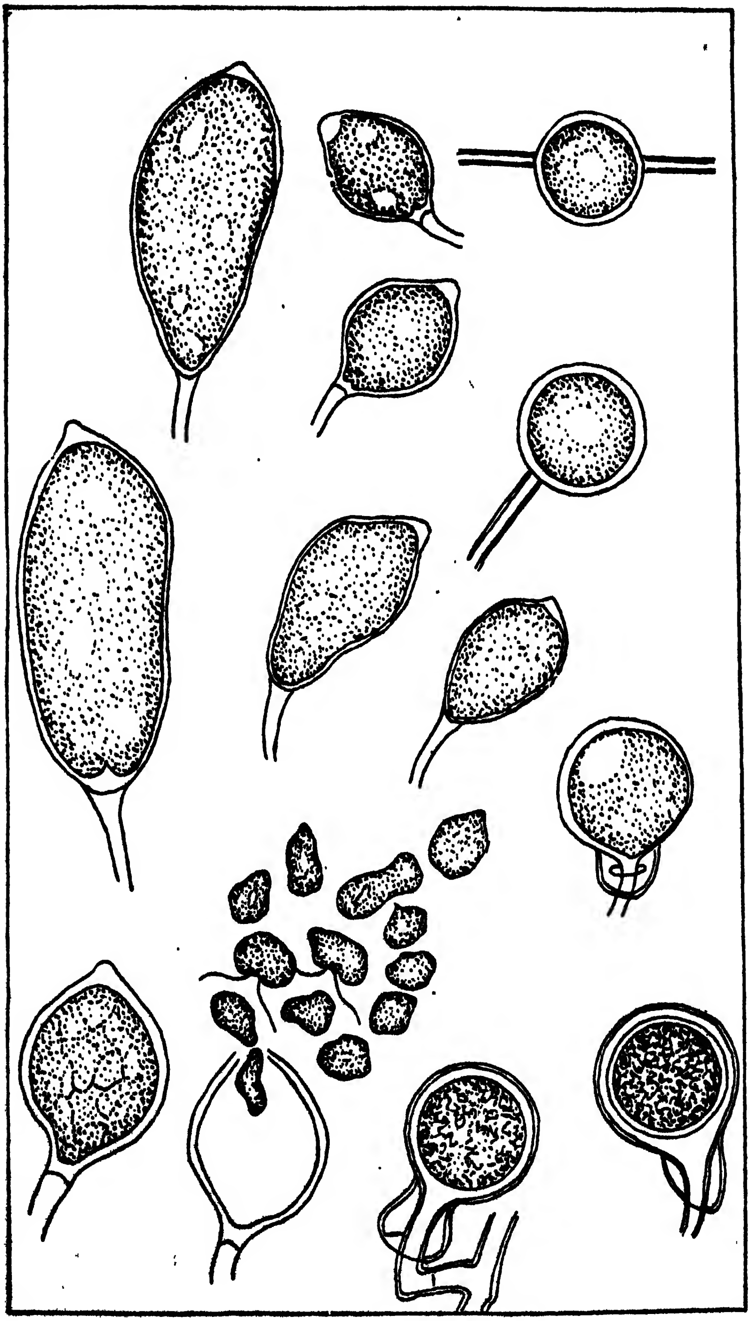

D
E
F
G

PLATE III.

Sporangia, zoospores, chlamydospores and oospores, of No. 9 (*P. colocasiae* Rac.), isolated from Sireh (*Piper Betle* L.), in Pahang, F.M.S.



THE

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Jelutong.

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Introductory.

An account was given in a previous number of the Journal, Vol. XVI, 1928, No. 5, page 204 of an investigation regarding the effect of the addition of certain metallic salts to jelutong in various stages of its preparation.

It was shown that while the effect of the addition of soluble iron and copper salts to the latex before coagulation was to cause oxidation of the product the addition of manganese appeared to favour mould development.

Owing to the fact that jelutong can become so easily contaminated with iron during its preparation a comprehensive series of experiments has been carried out in order to ascertain the stage at which iron has the greatest effect.

The experiments with copper and manganese salts have also been repeated for the purpose of confirming the preliminary observations.

With regard to the alleged increased tendency of Kedah jelutong to oxidation another visit has been made to the Jeniang concession for the purpose of carrying out further experiments with the fresh latex.

In addition, an investigation has been carried out regarding the storage qualities of jelutong in a creped form

in view of the contention that the material in this state is particularly liable to oxidation.

It may be of interest to mention that this point arose during the course of the investigation on the valuation of the material, a record of which was published in this Journal, Vol. XVI, 1928, No. 6, page 220. With the large number of blocks being tested for moisture content there was a considerable amount of surplus jelutong which it was decided to ship to New York. Reports were received, however, that on arrival the material was practically valueless owing to oxidation during transit. In view of the investigation being carried out at the time on the general question of deterioration due to oxidation the information was considered of sufficient importance to warrant carrying out further experiments on the storage qualities of creped jelutong by measuring the increase in the amount of the acetone soluble content of the material at monthly intervals.

1. The Addition of Metallic Salts.

(a) *The addition of soluble iron salts to latex before coagulation by standing.*—Duplicate blocks of jelutong were prepared by mixing 100 ccs of local latex with varying amounts of an 8.6 per cent solution of ammonium iron alum (1 cc. is equivalent to 0.01 grammes of iron) and coagulating with 0.2 ccs of 10 per cent sulphuric acid. Control experiments with sulphuric acid alone were also carried out.

Sulphuric acid was employed in preference to acetic acid, since experiments have shown that during the wet season sulphuric acid is a more reliable coagulant than acetic acid as regards degree of coagulation and further many producers use sulphuric acid regularly as a coagulant for their latex.

The coagula were removed after four days and the excess serum squeezed out by hand. In one series of experiments the blocks of crude jelutong were allowed to drain for two days and weighed, while in the other the coagula were refined by treatment with boiling water, the resultant blocks being also allowed to drain for two days and weighed.

Both sets of blocks were examined from time to time for signs of oxidation and when a block became so brittle that it broke on handling the material was ignited and the iron estimated.

The final examination of the blocks was made after four months.

The results of the experiments with the crude product, summarised in Table I, show that soluble iron salts present in the latex in very small proportions induce oxidation with relatively great rapidity and without any development of mould, also before any considerable reduction in the weight of the block has occurred owing to loss of moisture. This is all the more surprising since previous experiments have shown and confirmation has been obtained in the present series that with sulphuric acid as a coagulant the crude coagulum develops mould rapidly on storage.

It is interesting therefore to record that the presence of an amount of soluble iron equivalent to 1 part in 20,000 parts of latex causes the crude material to oxidise completely in approximately three months, the total iron present in the oxidised material being equivalent to only 60 per cent of the amount originally added.

Further, although the figures in the table show that between 45 and 60 per cent of the amount of iron added to the latex is present in the coagulum this amount of iron includes that present in the serum in the block. The amount of iron associated with the jelutong will be therefore considerably less than that found for the whole block. Assuming that the amount of serum in each block is approximately 20 ccs it will be seen that the estimated amounts of iron associated with the jelutong vary from 0.010—0.002 grammes.

With regard to the material refined by boiling with water none of the blocks became completely brittle, although as will be seen from Table II several showed considerable signs of deterioration due to oxidation after storage for four months. There is little doubt therefore that treatment with boiling water increases both the toughness of the material and its resistance to oxidation.

TABLE I.

Results of Experiments with the Crude Coagulum.

Volume of latex. ccs.	Amount of iron added grammes.	Equivalent volume of latex per gramme weight of metal. ccs.	Weight of fresh block. grammes.	Weight of block when analysed. grammes.	Loss in weight on storage. grammes.	Approximate period of storage for complete oxidation. weeks.	Amount of iron present in oxidised material including serum. grammes.	Proportion of original amount of iron added. per cent.	Estimated amount of iron present in oxidised material grammes.	Remarks.
100	.040	2,500	37.0	29.5	7.5	8	.018	45	.010	Material completely oxidised.
100	.020	5,000	38.5	29.5	9.0	9	.010	50	.006	Material completely oxidised.
100	.010	10,000	40.0	28.0	12.0	10	.005	50	.003	Material completely oxidised.
100	.005	20,000	40.0	23.5	16.5	12	.003	60	.002	Material completely oxidised.
100	.002	50,000	37.5	25.0	12.5					Development of black mould with specks of oxidised material.
100	.001	100,000	38.0	26.0	12.0					Development of black mould.
100	Nil	Nil	41.3	27.0	14.3					Development of black mould.

TABLE II.

Results of Experiments with the Refined Coagulum.

Volume of latex.	Amount of iron added.	Equivalent volume of latex per gramme weight of metal.	Weight of fresh block.	Weight of block when analysed.	Loss in weight on storage (4 months)	Amount of iron present in stored material.	Proportion of original amount of iron added.	Remarks.
ccs.	grammes.	ccs.	grammes.	grammes.	grammes.	grammes.	per cent.	
100	.040	2,500	39.6	35.2	4.4	.010	25	Outer layers of block oxidised to a depth of $\frac{1}{4}$ inch.
100	.020	5,000	39.6	33.9	5.7	.004	20	Outer layers of block oxidised to a depth of approximately $\frac{1}{8}$ inch.
100	.010	10,000	41.4	34.8	6.6	.003	30	Outer layer could be flaked off.
100	.005	20,000	41.9	36.6	5.3	.002	40	Outer layer commencing to flake.
100	.002	50,000	41.7	35.5	6.2	.001	50	Satisfactory.
100	.001	100,000	42.8	37.8	5.0	Traces		Satisfactory.
100	Nil	Nil	40.0	33.0	7.0			Satisfactory.

Compared with the corresponding blocks in the first series a reduction in the iron content will be noticed in every case. This is, however, only to be expected since the effect of boiling with water is to eliminate the soluble iron present in the serum, the material retaining probably only the iron associated with the jelutong on coagulation. In this connection it is interesting to note the relatively close agreement between the estimated amounts of iron associated with the jelutong in the case of the crude material and the amounts determined for the refined material.

Confirmatory results were obtained from experiments in which acetic acid was used as the coagulant and soluble iron was added both as ferric chloride and ammonium iron alum. For example, in one series in which acetic acid was used as the coagulant and soluble iron in the form of ferric chloride was added to the latex in the proportion of one part of iron to 5,000 parts of latex the crude material was completely brittle after two months storage, the iron present in the jelutong being approximately 40 per cent of the amount originally added.

Further, in another series of experiments in which acetic acid was used for coagulation and amounts of soluble iron in the form of ammonium iron alum were added to the latex in the proportions of one part of iron to 2,500 and 5,000 parts of latex respectively and the material refined by boiling with water, the blocks were completely brittle after 3 months and 4 months respectively. In both cases only approximately 33 per cent of the iron originally added was present in the oxidised material.

(b) The addition of soluble iron salts to latex before coagulation by boiling.—Similar series of experiments in which the jelutong was coagulated by boiling showed that the product was still susceptible to oxidation, even though the material was subsequently refined by boiling with water.

Thus, in a series of experiments in which acetic acid was used as a coagulant and soluble iron in the form of ferric chloride was added in the proportion of one part of iron to 5,000 parts of latex the material coagulated by boiling was completely oxidised after 4 months, while refining the jelutong by boiling with water resulted in the product holding up for an extra month before becoming brittle. The iron present in the material was in both cases equivalent to only approximately 35 per cent of the amount originally added.

In another series in which acetic acid was also used as the coagulant and soluble iron in the form of ammonium iron alum added in the proportion of one part of iron to 5,000 parts of latex, the jelutong being coagulated by boiling and refined by boiling with water, the material was completely oxidised after four months. Only approximately 35 per cent of the iron originally added was present in the oxidised material.

(c) *The coagulation of latex in rusty tins.*—Duplicate experiments were carried out in which jelutong latex was coagulated with sulphuric acid in both rusty and clean tins. The coagula were removed after four days, the serum being squeezed out by hand. In one experiment the blocks were allowed to drain and stored, while in the other the blocks were refined by treatment with boiling water previous to storage.

In the case of the crude blocks deterioration due to black mould quickly developed and although there were specks of what appeared to be oxidised material they were difficult to identify in the mouldy mass. With the refined blocks deterioration due to oxidation was more marked, since on examining the blocks it was noticed that a spot of rust was invariably surrounded by oxidised material.

(d) *The addition of insoluble iron to latex before coagulation by standing.*—Duplicate blocks of jelutong were prepared by mixing small quantities of very finely ground ignited iron oxide with latex before coagulation by standing, sulphuric acid being used as the coagulant. The amounts of iron added were equivalent to approximately one part in 7,500 and 15,000 parts of latex respectively.

The coagula were removed after the usual period, the excess serum squeezed out by hand and the blocks stored. In both cases deterioration due to black mould developed, the material showing no signs of oxidation although the particles of iron oxide were distributed throughout the blocks.

(e) *The addition of insoluble iron to latex before coagulation by boiling.*—Duplicate blocks of jelutong were prepared as in the previous series of experiments except that the material was coagulated by boiling. In this case also no deterioration of the material due to oxidation took place, even though the material was stored for four months.

(f) *The storage of the crude coagulum in water containing iron.*—Since it has been suggested that deterioration due to oxidation may be due to the jelutong absorbing iron from water in which it may be stored prior to refining a series of experiments was carried out in which the crude coagulum was soaked in water to which varying amounts of a suspension of ferric hydroxide in water had been added. The ferric hydroxide had previously been washed free from salts, and when shaken up with water some of the precipitate appeared to become colloidal so that the conditions as regards possible absorption of iron were as favourable as possible.

The concentrations employed varied from 40 parts to 1 part of iron in 100,000 parts of water. The liquid was stirred constantly each day in order to prevent the precipitate from protecting the coagulum. The blocks remained soaking for four days, after which they were refined by treatment with boiling water and stored.

The blocks showed no signs of deterioration due to oxidation after storage for four months even though in the case of the higher concentrations the material was brown in colour from contact with the ferric hydroxide.

(g) *The refining of jelutong by boiling in water containing iron in suspension.*—A similar series of experiments was carried out in which the crude coagulum after being soaked in clean water for two days was boiled in water to which varying amounts of ferric hydroxide had been added, the concentrations varying as indicated in the previous series

The blocks showed no signs of oxidation after four months storage, even though as in the previous series some of the blocks were brown in colour.

(h) *The surface treatment of the crude and refined coagulum with both soluble and insoluble iron.*—Duplicate blocks of material were prepared by coagulating latex with acetic acid, both by standing and boiling. When the blocks were shaped small depressions were made so that drops of liquid placed on the blocks would evaporate on the surface.

The blocks were allowed to dry for two days after which they were treated with drops of the following (a) 2 per cent solution of ferric chloride (b) 1 per cent solution of ferric

chloride (c) 8.6 per cent solution of ammonium iron alum (d) 4.3 per cent solution of ammonium iron alum (e) suspension of ferric hydroxide in water, while other blocks were pierced with rusty nails. The blocks were then stored for four months.

In the case of the jelutong coagulated by standing, none of the blocks showed any signs of deterioration due to oxidation, although all were affected by mould development. One or two blocks prepared by coagulating the latex by boiling showed signs of deterioration due to oxidation where the drop had been applied, but there was no tendency for the oxidation to spread.

(j) *The addition of copper salts to latex before coagulation by standing.*—Duplicate blocks of jelutong were prepared by mixing 100 ccs of local latex with amounts of copper sulphate equivalent to 1 part of copper to 2,500, 3,300, 5,000 and 10,000 parts of latex respectively and coagulating with 0.5 ccs of 10 per cent acetic acid. Control experiments with acetic acid alone were also carried out.

The coagula were removed after four days and the excess serum squeezed out by hand. In one series of experiments the blocks of crude jelutong were stored, while in the other the coagula were refined by treatment with boiling water before storage.

In the case of crude material there was no deterioration due to oxidation and with the exception of the control there was only evidence of deterioration due to development of mould in the case of the block in which the latex had been treated with copper in the proportion of 1 part to 10,000 parts of latex. None of the blocks of refined material showed any signs of deterioration due to oxidation.

(k) *The addition of copper salts to latex before coagulation by boiling.*—A similar series of experiments to the above was carried out in which the latex was coagulated by boiling, acetic acid being used as the coagulant. It is interesting to note that an increase in the proportion of copper results in a decrease in the degree of coagulation.

After four months storage it was noticed that in the case of the blocks prepared from latex to which copper in the proportions of one part to 2,500 and 3,300 parts of latex had been

added before coagulation the material was completely oxidised. With the lower concentrations of copper there was a tendency for the material to break short, especially after refining treatment with boiling water.

(1) *The addition of manganese salts to latex before coagulation by standing.*—Blocks of jelutong were prepared by mixing 100 ccs of local latex with amounts of manganese sulphate and manganese chloride equivalent to 1 part of manganese to 1,000, 2,000 and 4,000 parts of latex and coagulating with 0.5 ccs of acetic acid. A control experiment was carried out in which the same amount of latex was coagulated with acetic acid. It was noticed that the addition of manganese, especially in the higher proportions, inhibited coagulation.

The coagula were removed after four days and the excess serum squeezed out by hand. The blocks of crude jelutong were then stored.

The blocks were examined from time to time for mould development. Although in the case of those blocks in which manganese salts had been added to the latex an external stickiness of the block developed more rapidly than in the case of the controls, the final results did not indicate that the addition of manganese is associated with an abnormal mould development.

Remarks and Conclusions.

In general, the results may be said to confirm those obtained in the previous investigation.

It is clearly shown that of the three metals iron is of paramount importance as regards the development of deterioration due to oxidation and further that this metal has the greatest effect when present in a soluble form in the latex before coagulation. The addition of this metal in either an insoluble or a soluble form at a later stage in the preparation of the product appears to be without effect.

The experiments indicate that the amount of soluble iron affecting jelutong is so small as to suggest the possibility of some catalytic reaction when the material is exposed to air and, if a general improvement in the standard of Malayan jelutong as regards this particular form of deterioration is to

be effected, it will be essential to impress on all producers the necessity of eliminating this metal in a soluble form from the latex before coagulation.

In this connection it is considered advisable therefore to repeat the conditions necessary for the preparation of high quality material, the straining of the latex before coagulation, the employment of clean vessels for coagulation and the use of pure coagulants.

With regard to the preliminary straining of the latex it is of interest to note that the largest American purchaser of Malayan jelutong is already insisting on a modicum of cleanliness as regards adventitious matter, although in the writer's opinion clean coagulating vessels and pure coagulants are of much greater importance.

Our experiments have shown that badly rusted tins may result in local oxidation, but one of the more important sources of contamination undoubtedly lies in the employment of wooden boxes for coagulation, the boxes being made watertight by filling the interstices with clay. It is well known that Malayan clays contain iron in varying proportions, some of which is certain to pass into solution during coagulation in an acid medium.

Further, the large amount of unnecessary secrecy regarding the nature of the coagulant may be responsible for a certain amount of deterioration. Unless producers purchase chemicals free from iron and prepare their coagulant under conditions which do not allow of iron being dissolved in the acid medium it is quite likely that in their desire to keep the details of their coagulant a secret they may be introducing iron, at the same time being ignorant of its ultimate effect on the product.

It may be contended that there are other causes responsible for deterioration due to oxidation and that too much insistence is laid on the presence of iron, especially when it will be seen later that the presence of iron in the ash from jelutong does not necessarily indicate that the material is oxidised. Against this it may be mentioned that jelutong latex gives only a faint oxidase reaction and that it was not until soluble iron was added to the latex before coagulation that deterioration due to oxidation was ever obtained in material prepared in the Department, even though blocks have been stored for nearly three years.

Further, although the Forest Department have been producing jelutong on a commercial scale for nearly three years no report has ever been received regarding the oxidation of their product, the high quality of which is undoubtedly due to the adoption of the precautions outlined above.

A previous article on this subject in this Journal, Vol. XV, 1927, No. 11, page 404 contained a statement that jelutong latex from local forest reserves was unlikely to be affected by oxidation, since experiments had shown that the only type of deterioration affecting the material was development of mould in the crude product and that this could be controlled by treatment with boiling water. As stated above, it was not until soluble iron was added to the latex before coagulation that deterioration due to oxidation was ever obtained in material prepared in the Department and since it has also been shown that soluble iron can be introduced so easily into the latex in a proportion that will affect the resultant product these are considered sufficient grounds for maintaining that iron is one of the most important causes of oxidation.

At present there is no simple method of detecting the active iron in a block of fresh material. It is true that a test has been suggested in which the freshly-broken surface of a block is treated with a drop of acid and a drop of a soluble thiocyanate and if the well-known blood-red colouration develops the material is regarded with suspicion.

The writer is, however, of the opinion that such a test may lead to erroneous conclusions, since it has yet to be established whether iron can enter into chemical combination with one of the constituents of the jelutong and, if so, whether the iron in such combination is affected by treatment with acid and thiocyanate.

Further, since jelutong is prepared under such primitive conditions and contamination with iron is so easy it might happen that when testing the product in the manner described above the iron revealed by the test might be innocuous. Among the latter forms may be mentioned iron taken up by the material during refining either from the water or the iron vessel in which the treatment is carried out, also the press in which the blocks are shaped.

In the writer's opinion there is no doubt that if it were possible to persuade producers to use glazed earthenware pots or tin vessels free from rust for coagulation and to coagulate the latex with pure reagents oxidation in Malayan jelutong would be a negligible factor.

Compared with iron, the effect of copper is of minor importance since it is not present in latex and under normal circumstances it is not possible for copper to be present to the extent necessary to induce oxidation.

Soluble manganese salts added to the latex before coagulation are without action as regards oxidation, and it is also doubtful whether they produce abnormal mould development.

2. Kedah Latex.

In view of the differences found as regards the storage qualities of crude Kedah jelutong compared with the local product an investigation was made regarding the more important constituents of the latex similar to that carried out with latex from local forest reserves and described in this Journal, Vol. XV, 1927, No. 3, page 65.

Experiments regarding the amount of total solids obtained by evaporation, compared with that coagulated by alcohol, showed that for Kedah latex the excess of total solids obtained by evaporation is much less than in the case of local latex as the figures in the following table show:—

	Local latex per cent.	Kedah latex per cent.
Total solids (dried at 100°C) ...	19.87	21.34
Total solids (on ignition) ...	0.03	0.03
Solids (coagulated by alcohol) ...	15.54	18.94
Nitrogen (Kjeldahl)	0.025	0.026

The results indicate therefore that while with the local latex the excess solids, calculating the amount coagulated by alcohol as 100 per cent, amount to approximately 28 per cent there is an excess of only 13 per cent for Kedah latex.

A qualitative analysis of the residue left on ignition showed the presence as in local latex of varying quantities of calcium, magnesium, potassium, sodium, phosphate and carbonate.

Further, an approximate analysis of the solids not precipitated by alcohol showed the presence of constituents similar to those in local latex, namely sugars and gummy substances. The figures for both the nitrogen content of these solids and the amount of residue on ignition, calculated on a moisture-free basis, were also in close agreement with those found for local latex.

Duplicate experiments in which both acetic acid and sulphuric acid were used as coagulants showed that only in one instance was there any tendency for the crude material to develop deterioration due to mould, while the blocks refined by boiling with water showed no tendency to develop oxidation, even though stored for six months.

With regard to coagulation of the latex with alcohol experiments showed that there was no tendency for the product to develop oxidation on storage, even though the jelutong was creped before pressing into a block. The results obtained in the previous series of experiments as regards the tendency of the product when prepared in this manner to oxidise must therefore be regarded as abnormal.

Deterioration due to oxidation can be induced in the Kedah product by the addition of soluble iron to the latex before coagulation in the same proportion as found for local latex. Soluble copper and manganese salts added to the latex before coagulation have also similar effects on the resultant product.

Remarks and Conclusions.

The investigation shows that there is no evidence in support of the statement that Kedah jelutong is particularly liable to oxidation.

The latex contains a smaller proportion of serum solids than local latex and the product is therefore less liable to develop deterioration due to mould.

As far as can be judged therefore the alleged tendency of this jelutong to oxidation can only be ascribed to a greater degree of contamination of the latex with soluble iron before coagulation.

3. The Storage Qualities of Creped Jelutong.

As stated previously this investigation was carried out in order to ascertain whether as a result of passing jelutong between rollers the creped material was liable to oxidation.

Sample blocks of refined Malayan jelutong from various producers were obtained through the kind agency of Messrs. L. A. Dreyfus & Co., Singapore, while additional blocks of refined material were prepared in the Department both from local latex and from Kedah latex. In the case of the local latex the material was prepared by coagulation by boiling, but with the Kedah latex the latter was coagulated with alcohol in order to obtain additional confirmation of the previous results obtained with this coagulant as regards oxidation.

The jelutong was passed three or four times between crepeing rollers, the material being then cut into short strips and stored in an airy cupboard.

The acetone soluble content of the material was determined at the commencement of the period of storage and afterwards at monthly intervals, or until the material was completely oxidised and fell to pieces.

It was found that when the material was passed between crepeing rollers a small amount of iron, amounting to approximately .01 grammes per 100 grammes of dry product, was taken up. In one experiment therefore the rollers were covered with a layer of thick canvas in order to eliminate this source of contamination. In the case of the samples from the various producers there was an excess of iron, indicating that the material had also been contaminated with this metal at an earlier stage of its preparation.

The results of the various experiments summarised in Table III show that while there are definite increases in the acetone soluble content of the material from Malayan producers, calculated on a moisture-free basis, the variations in the figures for the material prepared in the Department either from local or Kedah latex are negligible, being within the range of experimental error for such a determination.

Remarks and Conclusions.

It appears therefore that in the case of the F. M. S. and Singapore refined jelutong the increased tendency to oxidation

TABLE III.

Results of Experiments showing Increases in Acetone Soluble Content of Creped Jelutong on Storage.

(The results are expressed as percentages on the moisture free material)

Period of Storage.	F.M.S. Sample No. 1.	F.M.S. Sample No. 2.	Singapore Refined.	Forest Dept. Latex No 1.	Forest Dept. Latex No. 2.	Kedah Latex coagulated with alcohol.	Kedah Latex coagulated with alcohol and rollers covered with canvas.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent	per cent.
Fresh ...	77.9	78.4	76 5	78.0	78.8	78.8	78.2
1 month ...	78.7	85.5	90 8	79.3	80.2	78.0	78.3
2 months ...	79.1	94.1	91.5	76 5	78.1	80.6	79.8
3 months ...	81.5	95.2	92.4	79.0	78.7	77.7	78.5
4 months ...	82.0	Material fell to pieces.	Material fell to pieces	78.3	78.2	77.7	79.4
5 months ...	85.6						

cannot be due to the small amount of iron taken up during the crepeing process seeing that the material prepared from both local and Kedah latex is unaffected. Further, in the case of the samples of F.M.S. material it is more than likely that the latex was also obtained from Selangor forest reserves so that the possibility of variations in the constituents of the latex is also practically eliminated.

Support is therefore lent to the theory that oxidation is due to other causes and, since there is an excess of iron present, it is not improbable that sufficient of this metal was present in a soluble form in the latex before coagulation to permit of the development of oxidation.

Summary.

The article describes certain experiments regarding the effect of the addition of certain metallic salts to jelutong at various stages of its preparation.

2. The results show that the addition of soluble iron in relatively small amounts to the latex before coagulation has a marked effect as regards inducing oxidation in the resultant product.

3. Experiments with Kedah latex show that there is no evidence in support of the statement that the product from that State is liable to oxidation.

4. A series of experiments carried out on the storage qualities of creped jelutong from various sources shows that the material in this form has no increased tendency to oxidation.

In conclusion the writer wishes to thank Mr. Gunn Lay Teik for his assistance in carrying out most of the analytical work in connection with the various investigations, also Messrs. L. A. Dreyfus & Co., Singapore, for their continued interest in the work and their kindness in providing the requisite samples for analysis.

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System of Land Tenure in Kelantan.

BY

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HISTORICAL.

Prior to the reign of Sultan Mulut Merah land in Kelantan was disposed of by the local headmen (To' Kweng) on behalf of the Ruler. In 1881 a system of registration of changes of ownership was introduced and in 1896 a land office was inaugurated at Kota Bharu by direction of Sultan Mansur. During the period 1881 to 1915 a large number of titles in varying forms ("chop lama", "miliki" and the like) were issued, many of which are still extant. These are being replaced, as rapidly as circumstances permit, by titles under Grant or Entry in the Mukim Register. Lands granted under the old forms of title were not surveyed, the situation, boundaries and in some cases the approximate area being as a rule roughly indicated by a sketch on the margin or back of the title. Prior to 1916 no quit rent was collected, the occupier paying a produce tax (*hasil padi* or *hasil buah*) to the State which was collected by the local headmen. This form of land tax still survives in a few Mukims in the extreme north-west of the State (Kelantan Bharu) where survey and registration of title have not yet been completed.

LAND LAW.

Up to the year 1926 the law governing the tenure of land in Kelantan was comprised in the Land Rules of 1914 and 1921 together with a large number of Notifications having the force of law which were promulgated at various times between 1910 and 1926. In 1926 a Land Enactment was passed and brought into force in August of that year, embodying the essential elements of land legislation according to the Torrens System. An amending Enactment introduced in 1928 has specifically repealed a large number of Notifica-

tions, which were either obsolete or conflicted with the principal Enactment. The 1926 Enactment was not designed to be the final expression of the land law of Kelantan and a comprehensive Land Code, based in the main on the Federated Malay States Land Code of 1926 with such modifications as local conditions may require, is now in course of preparation.

Organisation.

For purposes of land administration the State is divided into three districts

(i) Kota Bharu, including the sub-district of Pasir Mas

(ii) Ulu Kelantan

(iii) Pasir Puteh, including the sub-district of Bachok.

Each District is in charge of a European District Officer, with Malay Assistant District Officers for the sub-districts of Pasir Mas and Bachok. The District Officer, Kota Bharu is, in addition, Registrar of Titles for the State. The District Officers and Assistant District Officers have under them one or more Malay Assistant Collectors of Land Revenue with similar legal powers. Districts are sub-divided into Daerahs, each under the control of a local headman known as a Penggawa. The Daerah again is subdivided into a number of Mukims. The Mukim is the unit for survey and land registration.

Alienation and Methods of Tenture.

The following varieties of land are recognised by law: —

(a) Town Lands

(b) Country Lands under 10 acres in area

(c) Country Lands of 10 acres in area and upwards.

All land which is neither alienated nor reserved and on which no rent is paid to the State is deemed to be State Land.

Town Land. The document of title for town land is a Grant or a Lease of State Land, usually the former. A Grant conveys an absolute title in perpetuity subject to the payment of the annual quit rent and to the observance of the general

conditions implied in the Land Enactment and to any special conditions which are expressly set forth in the Grant. A lease conveys such rights and interests as are set forth in the document of lease and runs for a definite term of years prescribed in each case by His Highness the Sultan in Council. Alienation of town lands is usually carried out by auction, the sum due on account of premium, survey fees, cost of boundary stones and fees for preparation and registration of the document of title being included in the upset price.

Country Lands under 10 acres in Area. The title for land of this category is since the passing of the Land Enactment 1926, an entry in the Mukim Register, but the work of entering up old alienations in the Registers is still far from complete and a large number of old forms of title are still extant. In the absence of an Entry in the Mukim Register, the entry in the Settlement Index constitutes a temporary title pending the preparation of the Mukim Register. The Entry in the Mukim Register gives an absolute title to land and where survey, or revision survey, by theodolite has been completed an Extract from the Mukim Register, with a plan of the land as surveyed endorsed thereon, is issued to the registered owner.

Country Lands of 10 acres in area and upwards. The title for this class of land is a Grant or Lease of State Land, usually the former. The scale of premium and rent has recently been raised but provision is made for variation within wide limits according to the quality and accessibility of the land applied for and for specially favourable terms in respect of the cultivation of new agricultural products which it is desired to encourage.

Applications for Land.

Applications for State Land should be addressed to the District Officer of the District in which the land is situated, and should be made in writing accompanied by a sketch map of the land applied for, together with full details as to the purpose for which the land is required. In the case of application for large areas an interview with the District Officer is advisable.

The legal authority for all alienation is His Highness the

10 acres in area is delegated, subject to certain restrictions, to the District Officers. The approval of an application is conveyed through the District Officer, who will inform the applicant of the amount to be paid or deposited by way of premium, survey fees and quit rent and will indicate the nature of the special condition, if any, imposed and the form of title under which the land is to be held.

Occupation prior to survey may be allowed with the permission of His Highness the Sultan or, in the case of areas under 10 acres, of the District Officer, provided all fees and dues are first paid or deposited and the boundaries of the land are marked out to the satisfaction of the District Officer, but such approval implies no claim on the part of the applicant to a greater area than that originally applied for.

On completion of survey and settlement of all fees and dues the District Officer will obtain the issue copy of the document of title from the Registrar of Titles and will deliver it to the applicant.

A precis of the Premium and Rent Rules, 1928, showing the scale of premia and rents now in force for the different categories of land, is given in Appendix A.

Quit Rent is payable on the 1st January in each year at the District Land Office, without demand. Any quit rent not paid by the 30th April is deemed to be an 'arrear' and is recoverable by process of law. Notices of Demand are issued and if not complied with by the 30th June the amount due is recoverable either by the attachment and sale of the moveable property of the defaulter or by attachment and sale of the land, or any part of it, in respect of which default of rent has been made. The District Officer may employ either of the above methods of recovery, at his discretion.

Cultivation and Special Conditions.

The following extracts from the Land Enactment 1926 deal with the obligations imposed by law on the registered owner of country land in respect of cultivation:—

"Unless it is otherwise specifically provided by special condition endorsed on the original document of title or in the Mukim Register all alienated lands are subject to the following conditions respecting cultivation:

"(a) Where the title covers an area of more than fifty acres the land described therein shall be cultivated to the extent of not less than one tenth within one year from the date of registration of title and to the extent of one quarter within five years from the date of registration of title.

"(b) Where the title covers an area not exceeding fifty acres the land described therein shall be cultivated to the extent of not less than one quarter within one year of the date of registration of title and the whole within four years of the date of registration of title."

Any land may be alienated subject to such special conditions relative to buildings, cultivation or upkeep as His Highness the Sultan in Council (or, in the case of holdings less than 10 acres in extent, the District Officer) may see fit to impose.

Breach of special conditions or of cultivation conditions renders the land liable to forfeiture and resumption by the State.

Surveys.

A Survey Department was organised in Kelantan in 1911, and between the years 1911 and 1926 virtually the whole of the occupied portion of the Kelantan coastal plain, comprising the majority of the Districts of Kota Bharu and Pasir Puteh and containing approximately 300,000 holdings, was surveyed by plane table. Concurrently with this survey Settlement Indices were prepared for each Mukim and Rent Rolls compiled. As the record of each Daerah was completed the collection of quit rent on acreage was substituted for that of produce tax. The record of occupation provided by the Settlement Index was recognised as evidence of a valid and transmissible title of land, pending the preparation of the Mukim Registers.

Concurrently with the progress of the plane table survey the survey by theodolite of town lands and of extensive areas of estate lands was carried out.

In 1926 it was decided that plane table survey should be discontinued and that all future survey should be carried out by theodolite. No title is now issued except after theodolite survey. The revision survey of the large areas of small hold-

ings surveyed by plane table prior to 1926 will be a task involving the expenditure of much time and money.

In the case of new applications for land of less than 10 acres in extent, the area is demarcated by the demarcation staff of the District Office, a lot number is assigned by the Survey Office after plotting on Survey Office maps and the holding entered in the Settlement Index and Rent Roll, the applicant being placed in immediate possession pending the fulfilment of the requisition for survey. An applicant for a larger area e.g. for estate cultivation, could ordinarily count on the completion of survey within a reasonable period, permission to occupy prior to survey being as a rule readily obtained.

The new scale of survey fees, which was brought into force in 1928, is given in Appendix B.

CONCLUSION.

The coastal plain of Kelantan consists of a fertile alluvial area of approximately 1,000 square miles, roughly rectangular in shape, having a length of about 60 miles and an average breadth of 25 to 30 miles. Almost the whole of this area is intensively cultivated by a hardy and industrious peasantry; the population is of a remarkable density, being slightly over 230 persons to the square mile; the average size of the native holding is about one acre. This area comprises the bulk of the Districts of Kota Bharu and Pasir Puteh and within it there is little land left available for alienation, except such as is required to fulfil the constant demand for small holdings for native cultivation, and the unalienated area is steadily diminishing in extent. The total cultivable area available for alienation in Kota Bharu and Pasir Puteh Districts probably does not exceed 30,000 acres, of which a considerable proportion is in Kelantan Bharu, the extreme north-west portion of the State, and is consequently difficult of access.

The bulk of the European-owned estates are situated in the District of Ulu Kelantan and here there are large tracts of land available for alienation, the estimated extent of which is computed to be some 4,300 miles much of which, however,

is mountainous and difficult of access. The District is traversed by the road from Kota Bharu to Kuala Krai, the district headquarters, 53 miles from the coast, and by the Federated Malay States railway which is completed and open to traffic as far as Manek Urai, 8 miles beyond Kuala Krai. At a rough computation there may be said to be 300 to 500 square miles of cultivable land within reasonable distance of the road and the railway. The completion of the latter should stimulate the demand for land for estate cultivation in the interior of the State.

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APPENDIX A.

Precis of Premium and Rent Rules (Kelantan) 1928.

I. *Town Lands.*

(i) Alienation generally by auction. The reserve price on lands sold by auction and the premium payable in the case of lands not sold by auction to be fixed in each case by His Highness the Sultan in Council.

(ii) Annual rent to be such as is fixed in each case by His Highness the Sultan in Council, with the following minima:—

Building lots of 2,400 square feet or less, per lot $2.00.

Building lots of more than 2,400 square feet, at the rate of $2 for every 2,400 square feet or part thereof.

Town lands (other than building lots), $5 per acre.

II. *Country Lands.*

(A) Premium:—

(i) On Country Lands (a) of less than 10 acres in area and (b) between 10 and 20 acres in area:—

Rice land, $5 to $15 per acre.
Kampong land, $10 to $15 per acre.
Rubber land, $15 to $25 per acre.

(ii) On Country Lands of 20 acres in area and over:—

If the cultivation of rubber is prohibited, not less than $10 nor more than $25 per acre; if the cultivation of rubber is not prohibited, not less than $20 nor more than $50 per acre.

Notwithstanding the above, His Highness the Sultan in Council may fix special rates in special cases.

(B) Annual Rent:—

(i) On Country Lands of ten acres in area and over: One dollar per acre per annum for the first six years and thereafter three dollars per acre per annum.

(ii) On Country Lands of less than ten acres in area:
Rice land, $0.40 to $1.
Kampong land, $0.80 to $1.60 cents.
Rubber land, $1.20 cents to $1.40 cents.

APPENDIX B.

SURVEY FEES.

A. In the case of agricultural land of less than 10 acres in area held and to be held by Entry in the Mukim Register the cost of survey fees and boundary marks shall be included in the premium charged.

B. In all other cases, except those Town Lands for which special rates are allowed under rule C, the following shall be the fees prescribed for survey:—

5 acres and under	...	$25.00
For each additional acre up to 10 acres		4.00
10 acres	...	$45.00
For each additional acre up to 25 acres		3.00
25 acres	...	$90.00
For each additional acre up to 50 acres		2.00
50 acres	...	$150.00
For each additional acre up to 100 acres		2.00
100 acres	...	$250.00
For each additional acre up to 200 acres		1.00
200 acres	...	$350.00
For each additional acre up to 300 acres		.90
300 acres	...	$440.00
For each additional acre up to 500 acres		.80
500 acres	...	$600.00
For each additional acre up to 1,000 acres		.70
1,000 acres	...	$950.00
For each additional acre above 1,000 acres		.60

C. For town lands the fees prescribed shall be:—

For lots not exceeding 2,400 square feet in area, per lot	...	$10.00
For lots exceeding 2,400 square feet but less than one acre in area, per lot	...	$15.00

For lots exceeding one acre in area the fees prescribed in Rule B.

Chemical Investigations on Coconuts and Oil Palm.

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Ag. Agricultural Chemist.

The following article is based on a paper read by the writer at the Bagan Datoh Club, Lower Perak, on April 4th 1929.

Introductory.

Apart from rubber and from the point of view of estate agricultural practice the two most important crops at present being cultivated in Malaya are coconuts and oil palm. It is only reasonable therefore that these crops should be made the subjects of special investigations as far as the Department of Agriculture is concerned.

There is no need to emphasise the importance of coconuts either from the point of view of general cultivation or of an estate crop. The latest returns show that at present approximately 168,000 acres are planted with coconuts in the Federated Malay States, approximately 60,000 acres being under European management. In the case of oil palms, that have only become established as a major crop during the past few years, there are in Malaya approximately 24,000 acres already planted together with a further 27,000 acres of reserve land not planted or in course of planting, while other large areas of land have also been reserved provisionally for this crop.

Both coconuts and oil palm have their own special lines of chemical investigation, and in this paper I shall endeavour to outline briefly those points with which the Chemical Division is at present more especially concerned. In this connection I hope that you will not be disappointed if I devote rather more of my time to a consideration of the chemical problems connected with oil palm. The reason is chiefly personal, for, while I have been working for the past two years on oil palm products, it is only recently that I commenced any coconut investigations. Further, those of you who have

studied the oil palm industry or visited oil palm factories will realise the importance of the many chemical problems connected with the preparation of high quality oil palm products. The oil palm factory marks the commencement of what may be termed technical estate practice. Compared with coconuts, oil palms are not an easy crop and the estate manager, unless he is so fortunate as to serve on an estate large enough to enable him to devote himself to field work and to allow of the employment of a separate manager for the factory, will find it necessary to pay special attention to the factory process if he wishes to maintain a high quality of products.

I think there is every reason to believe that under suitable conditions oil palms will prove on the average a more remunerative proposition than coconuts, although in the case of the former crop the initial outlay is heavier on account of the relatively large factory capital charges, which amount to approximately £5—£6 per acre.

The necessity for such a relatively heavy outlay is explained by the fact that the more valuable constituent of the fruit, palm oil, must be recovered with the least possible delay after harvesting if high quality oil is to be produced.

Coconuts.

The principal investigation being carried out at present in the Division is the establishment of standards for the oil content of Malayan Estate copra.

Reports have recently been received from London that the value of Straits copra is tending to deteriorate owing to a reduction in oil content and statements have been made that whereas Straits copra formerly had an oil content of 66/67 per cent of oil and yielded 63/64 per cent of oil, recent shipments had been found to contain only 63/64 per cent of oil yielding only 60/61 per cent of oil. The establishment of standards for Estate copra appears desirable, especially in view of the fact that before export Estate copra is sometimes mixed with native copra, the latter being frequently inferior both in quality and oil content.

Six estates distributed throughout Malaya are therefore forwarding during a period of six months regular monthly

samples of their copra. These samples, amounting to approximately 5 lbs., are analysed and the results reported to the individual estates. In due course a summary of the results of the investigation, in which the estates will be referred to by letter or number, will be published in this Journal.

It may be of interest to you to know that the variations in the 17 samples examined to-date are as follows:—

	Maximum per cent.	Minimum per cent.	Average per cent.
Moisture ...	8.2	4.7	6.4
Oil (on sample as received)	62.9	57.7	60.6
Oil (on moisture-free basis)	66.9	62.3	64.7

The comparatively wide variations in moisture content are interesting and point to the necessity of an investigation into the most economical method of drying the fresh meat.

If we divide the figures for the oil content of the copra, calculated on a moisture-free basis, into three groups, 62—64 per cent, 64—66 per cent and 66—68 per cent we find that of the 17 samples examined four fall in the first group, eleven in the second group and two in the third group. This indicates therefore that apart from seasonal variation the present oil content of estate copra, calculated on a moisture-free basis, probably lies within the limits 64—66 per cent.

Although the investigation has only been proceeding for about two months it appears probable that the full results will be in agreement with those obtained to date. All the same I hope that those who are interested in the subject will study the summary of the whole investigation.

As a result of this work the next step will be to decide whether it is not possible either to improve the oil content of the copra from present palms or to breed other palms having a higher oil content.

The reason for the relatively low oil content is difficult to explain and may be due to one or other of a variety of causes, probably a combination of causes. Among the reasons that suggest themselves are the climate, the state of ripeness of the

nuts when picked, a low yielding strain, lack of cultivation, unsatisfactory drainage and unsuitable soil conditions.

As regards the first possibility it is well known that on account of the equable and moist climate of Malaya there is rapid germination of the ripe nuts even while still on the palms, particularly as many estates do not pick at intervals of less than two months. An examination of the piles of nuts on estates shows quite a material percentage of germinations. There is little doubt also that the meat of a germinated nut is slightly deficient in oil content owing to the enzyme action produced by germination.

This question would point therefore to a problem in economics as to whether it would not be preferable to pick at shorter intervals if such a procedure produced copra of higher oil content.

Experience with oil palms has shown that the state of ripeness of the fruit has a direct effect on the oil content of the pericarp, and it is probable that the oil content of the coconut is affected in a similar manner.

Variations in many characters exist in all crops and it is certain that the coconut is no exception to this rule. The question of variation in coconuts as regards fruiting qualities is already engaging the attention of the Department, particularly the Botanical Division, and it has been found that the coefficient of variation in the number of nuts produced per annum is as high as 34 per cent of the mean production per palm under average estate conditions. The study of variation has also revealed the fact that 19 per cent of the palms on the average estate are unprofitable. Fruiting characters of individual palms have been found to be definitely constant over a period of 8 years and no doubt this constancy also exists as regards the oil content of copra from individual palms within the range of seasonal variation. This latter investigation is already in hand and although approximately 400 samples of copra have already been analysed this number is scarcely sufficient to overcome the effect of seasonal variation.

Oil Palm.

Before dealing with the various points of chemical interest as regards the preparation of oil palm products and illus-

trating the necessity of chemical control it would be advisable to give the average composition of the fresh fruit and also to outline briefly the method of factory treatment. As regards the latter I hope that the sheets, which have already been handed round and on which the process is shown diagrammatically, will be of value in helping you to follow the various stages of the treatment.

The following table gives the approximate composition of fresh oil palm fruit:—

		Per cent.
Pericarp	... ...	57—60
Nut	... ...	40—43
Pericarp	Moisture	36—40
	Oil	47—51
	Residue	14—16
Nuts	Shell	78—82
	Kernel	18—22
Palm oil (calculated on fresh fruit)	...	29—30
Kernel (calculated on fresh fruit)	...	7— 8

The above figures, which refer to the fully developed fresh ripe fruits, can only be regarded as approximate since experiments show that it is difficult to select average samples of fruit from a consignment. The problem of selection of average material for analysis becomes even more difficult when a bunch of fruit is considered, since the latter contains fruits in all stages of development and therefore of varying oil contents.

Analysis of the fruit from the point of view of oil content is therefore not usually attempted directly, the oil content of the bunch or of the fresh fruit being calculated indirectly. The amounts of oil lost at various stages of the process are estimated and by adding these amounts to that

of the oil recovered measures of both the oil content of the bunch or the fruit and also of the efficiency of the process are obtained.

As regards the treatment of fruit the latest process consists in the sterilisation of the bunches with steam under pressure. The bunches are then stripped, the sterilised fruit being transferred to a digester in which the fruit is mashed or pulped. The bulk of the pericarp oil, approximately 85 per cent, is then removed either by pressing or centrifuging the pulped mass. Both methods of treatment of the mash have been included in the diagram since they are both used in practice, the press system being favoured in Sumatra, while the centrifugal system has been adopted in this country.

At this point in the treatment there are two intermediate products, crude palm oil and a mass consisting of nuts and pericarp residue.

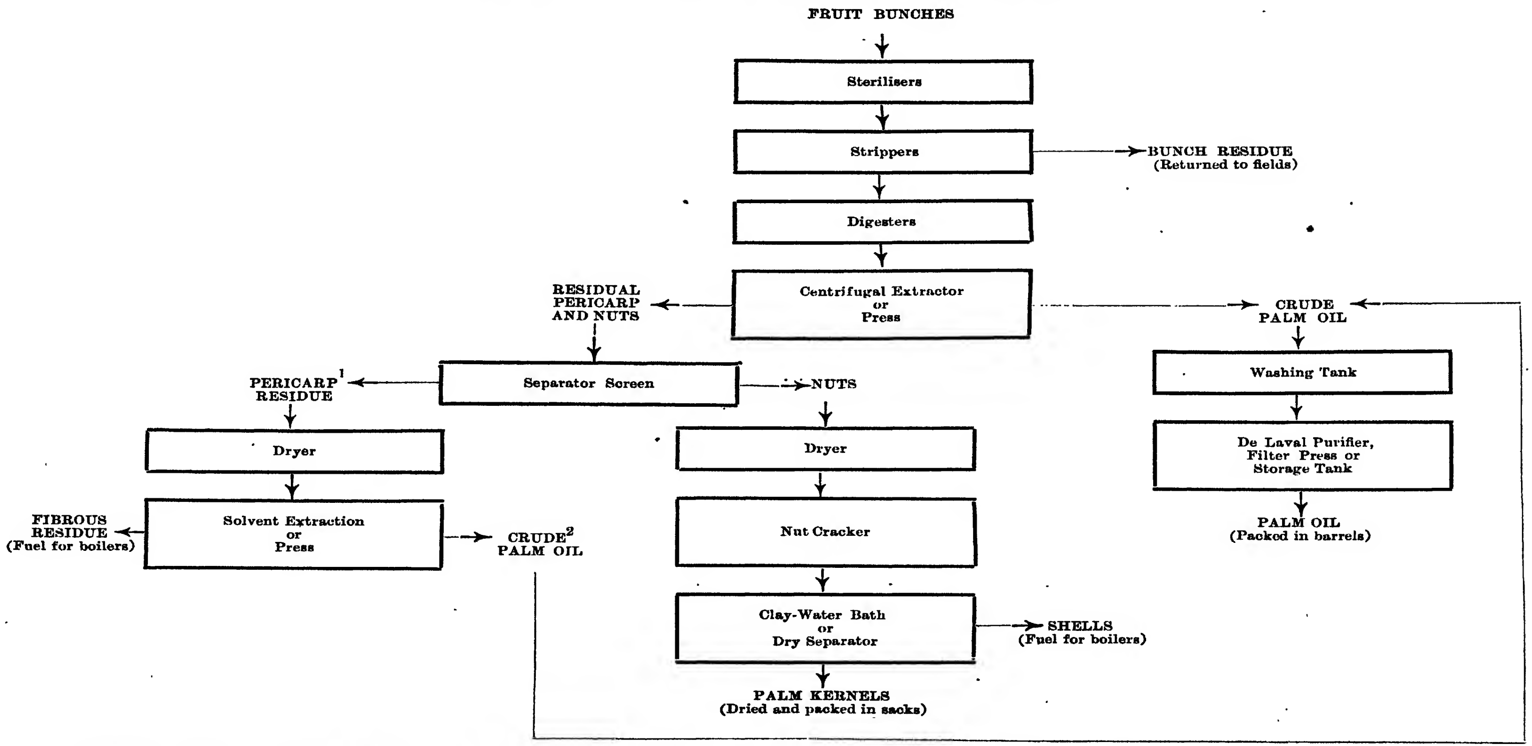
The crude oil is purified by agitation with live steam, after which it is allowed to stand and the almost clear supernatant oil transferred to a storage tank for a further period of settling or the oil can be purified by passing direct from the washing tank through either a centrifugal separator of the De Laval type or through a filter press. The oil is then packed in barrels for export.

The mass of nuts and residual pericarp is screened in order to separate the material into its constituent parts, the nuts being dried and cracked in a nut cracker, usually of the centrifugal type. The broken shells and kernels are separated in a suspension of clay in water, although there is little doubt that ultimately a dry method of separation will be evolved. The machine will work on the principle that kernels owing to their more rounded shape tend to roll faster than the broken particles of shells on an inclined plane moving in the opposite direction.

The kernels, which still contain from 10 to 12 per cent of moisture, are further dried before packing in sacks for export.

Although the details of the treatment of the pericarp residue have been included in the diagram the present prac-

DIAGRAM SHOWING FACTORY PROCESS FOR TREATMENT OF OIL PALM FRUIT



1. The subsidiary treatment of the pericarp residue is not at present practised in Malaya, the pericarp residue from the separator screen being used as fuel.
2. When high grade oil is being prepared it may be advisable to treat the crude palm oil from the second pressing or solvent extraction in a separate installation and market as second grade oil.

tice in Malaya is merely to use this material as fuel. Experience in Sumatra, where the oil palm industry is developed to a much greater extent than in Malaya, has shown that the subsidiary treatment of the residue, either by second pressing or solvent extraction, is only an economical proposition for large estates, 3,000 acres and upwards in full bearing, on which there is sufficient residue to maintain a plant in continuous operation.

Both the second pressing and solvent extraction method are in use in Sumatra. As regards recovery of oil the latter method has the advantage, since it is possible to recover practically the whole of the oil in the pericarp residue, including that on the surface of the nuts, by treatment with solvent. With the second pressing approximately only half the remainder of the oil in the pericarp residue is obtained, the total recovery of oil with two pressings amounting to approximately 92 per cent.

Mention might be made here of a process that is being developed for the treatment of the whole fruit by solvent extraction. Undoubtedly this is an ideal method of treating the fruit, since the whole of the oil can be recovered in a single operation. There are, however, difficulties to be overcome, among which may be mentioned the losses of solvent and the relatively high moisture content of the fruit. The latter would necessitate the removal of a very large amount of water from the digested mash in order to obtain the maximum effect of the solvent, also there is the possibility of some of the mucilaginous matter present in the fruit dissolving in the oil, thereby affecting its storage qualities. It is quite possible, however, that such a method may eventually be employed, although at first sight it appears preferable to recover the greater part of the oil by a simple process of pressing or centrifugal extraction and then the remainder of the oil by solvent extraction.

Although the factory process may appear complicated it is in reality only a sequence of simple operations, the whole process being designed to secure the maximum yield of high quality products with the minimum amount of manual labour.

The entry of Sumatra and more recently Malaya with their well-established estate organisation methods into the oil palm industry is resulting in the production of increasing

quantities of high grade oil palm products, particularly palm oil of a low acidity. Up to a few years ago the whole of the world's supply of oil palm products came from West Africa, the bulk of the palm oil being of a much inferior grade to that produced under estate conditions owing to the primitive methods of preparation of the oil. Unless therefore the average quality of the West African oil is greatly improved it is unlikely that for several years to come plantation palm oil will compete to any extent with the West African product, since it is anticipated that plantation palm oil will be used to meet the ever-increasing demand for high grade oils and fats for edible purposes as soon as large and regular supplies of the oil are forthcoming.

It will be realised that with such a technical process chemical control is a necessity, firstly since the value and application of the principal product in the industry is so largely affected by its acidity and secondly that with such a high capital outlay on plant it is important to ensure that maximum yields of products are being obtained.

The greater part of the chemical work on oil palm during the past two years has therefore been concerned with the factory side of the crop, although there is one investigation now in progress to which attention might be drawn, namely the removal of plant nutrients from the soil by the palm. It is realised that with the relatively large numbers of fruit bunches harvested annually artificial manures will have to be employed to maintain yields and a knowledge of the amount of plant nutrients removed in this way will be of some assistance when arranging details of manurial experiments.

As mentioned previously chemical control in an oil palm factory begins directly the bunches of fruit are weighed since a low yield of oil is frequently due to the bunches being picked slightly unripe. In order to obtain the maximum production of oil it is essential not to harvest the fruit bunch until ripe, as it has been definitely established that when a bunch of fruit is harvested the process of ripening ceases as far as the development of oil in the pericarp is concerned. The increase in oil content found with fruit stored for a few days before treatment is merely due to a decrease in the moisture content of the pericarp resulting in an apparent increase in the oil content. In order therefore to obtain comparable results it is essential that the procedure on an estate

should not vary and from that point of view the process of dealing with fresh bunches has much to recommend it, since direct comparisons between the weight of fresh bunches harvested and the weights of products recovered can be obtained.

Although the method of sterilising bunches requires an efficient transport system on the estate the method has the great advantage of dispensing with collecting sheds, thereby saving labour in the field. Further, since the fruit is not bruised to the same extent as when separated in the field, it is possible to produce an oil of lower acidity.

The acidity of the oil produced in an estate factory from fruit previously separated in collecting sheds varies from 3 to 4 per cent, calculated as palmitic acid, but by sterilising the bunches the acidity of the oil can be reduced to between 2 and 3 per cent, so that it is possible to guarantee the acidity of oil on arrival in Europe to be less than say 3.5 per cent. If fruit be sterilised immediately after harvesting it is possible to recover oil with an acidity of only 0.5 per cent so that the increase of say 1.5 per cent in the case of the bunches and 2.5 per cent in that of the fruit is due to the bruising of the fruit during transport from field to factory.

Slightly increased yields of oil are obtained as a result of sterilising the bunches under pressure owing to the coagulation of the gummy and albuminoid matters present in the fruit not affecting the extraction of the oil.

Our chemical investigations have shown that with the centrifugal system better results are obtained with a closed type digester working under slight steam pressure (Manlove Alliott type) than with a digester of the open kettle type. In the latter the mash becomes too thick and does not yield its oil so readily during the process of centrifugal extraction.

It is not proposed to discuss the merits of presses and centrifuges except to state that as regards the treatment of the whole fruit, and judged by the oil content of the pericarp residue, similar results are obtained by the two systems. From the point of view of cost the press is somewhat cheaper than the centrifuge, because the unit capacity of the latter is greater than the former but when a large installation, comprising several presses or centrifuges, has to be considered the difference is reduced considerably.

I have no experience of the purification of oil from presses, but the centrifugal system yields a crude oil that contains only relatively small proportions of sludge and moisture and is therefore easily purified in the manner already described.

During the past year between 50 and 60 samples of oil from various estates in Malaya have been examined and in no case has the dirt (matter in suspension) been found to exceed 0.02 per cent, rarely 0.01 per cent. The moisture figure has been found to vary from 0.15 to 0.45 per cent.

Palm oil increases in acidity on storage, the rate of increase varying with the amounts of moisture and matter in suspension. The latter consists of cellular debris and traces of mucilaginous matter and should therefore be reduced to a minimum.

Experiments have recently been carried out with a De Laval separator and the results show that, although the moisture content of the oil can be reduced to approximately 0.10—0.15 per cent, it is not always possible to remove the small amount of matter in suspension in the oil. In order to effect this successfully the oil would have to be heated to a temperature slightly exceeding 100°C in order to effect coagulation when separation would be a simple matter. One factor in favour of a De Laval separator is, however, the elimination of the personal element as regards the possibility of any sludge becoming mixed with the oil and, if the oil is to be used for edible purposes, the installation of such a machine on a large estate is recommended.

The average quality of Malayan estate palm oil, commencing with fresh fruit as the initial material in the factory, is as follows:—

	Per cent.
Acidity (calculated as palmitic acid) ...	3.0 —4.0
Moisture ...	0.25—0.35
Matter in suspension ...	nil—0.01

The increase in acidity of oil of this quality is approximately 0.1 per cent per month so that by determining the

acidity of the freshly prepared oil it is possible to estimate with a fair degree of the accuracy the acidity of the oil on arrival at its destination. The determination of acidity of palm oil in a modified form is therefore part of the routine in all oil palm factories.

Although strictly speaking the subject does not fall within the scope of this paper I should like to mention the question of shipment of oil. At present barrels are used exclusively, the cost is heavy, amounting to 1¾ cents per lb. of oil. This sum represents a considerable proportion of the total cost of production. Although it is certain that from the point of view of small consumers shipment in barrels will always be required it is more than probable that in a few years time bulk shipments of oil will be made. Such a method would require a separate organisation, since it would not be possible for any particular estate to incur the large capital expenditure necessary. In view of the developments in Sumatra as regards this method of shipment and of the far-reaching benefits that would have resulted had other industries organised themselves in the past it is a matter for consideration whether some kind of oil palm organisation should not be started in order to keep abreast of the development of the industry. There is no doubt that there will be competition in the future in the oil palm products market and it seems advisable therefore to make preparations against this contingency.

In this connection both in view of the technical nature of the factory process and the necessity of chemical control the installation of small chemical laboratories for large estates or groups of smaller estates, in which routine analyses such as those indicated above can be carried out, is recommended.

The subsidiary treatment of the nuts and pericarp residue calls for little comment except to state that the separation of the material from the centrifugal extractor can be effected without previous drying. From the chemical point of view the analysis of the fibrous residue is important, since it gives an indication as to whether the digester and centrifugal extractor are working satisfactorily.

Since kernels are sold on their oil content as received at their destination it is essential to ship them as dry and as

clean as possible, although owing to the humidity of the atmosphere in Malaya it is impossible to avoid small losses in weight during transit owing to evaporation of moisture.

Conclusion.

Such therefore is a brief outline of the more important chemical investigations at present being carried out with coconuts and oil palm. As you will realise much still remains to be achieved before our aims are reached, especially as regards the oil palm industry, which is still in its infancy as far as Malaya is concerned. It is however only by close co-operation between planters, scientific officers and manufacturers that the desired results can be obtained and in this connection I should like to impress upon you all that the Department of Agriculture is keenly interested in these two crops, the development of which is bound to contribute materially to a broadening of the basis of Malayan agricultural practice.

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Observations on the Dwarf Coconut Palm in Malaya.

By H. W. Jack & W. N. Sands.

Introduction.

The three dwarf and closely allied races of the coconut palm, which are of increasing economic importance locally, are those with ivory-yellow, apricot-red and green fruits respectively. These palms were fully described by us in a previous paper (1) where also, the results of certain observations and experiments that had been made in connection with their vegetative and flowering characters were given. It was shown that the flowers were, as a rule, self-pollinated, and that a high percentage of the resulting fruits bred true to type even when exposed to cross-pollination. It was also shown that it was possible to make a fairly accurate separation of the dwarf races from hybrid and tall forms by noting the growth and the colour characters of young plants in the nursery.

For the purpose of obtaining additional information concerning the palms, fruits of each of the three races were obtained in June, 1921, from open pollinated palms in a large plantation where dwarf forms were mainly grown. The nuts were germinated in Kuala Lumpur and afterwards transferred to Parit Buntar in the State of Perak where they were planted in the compound of the office and store of the Botanical Division of the Department of Agriculture. The soil there is an

(1) The Dwarf Coconut in Malaya, H. W. Jack and W. N. Sands. Vol X. No. 1, 1922.

alluvial clay-loam with a high percentage of organic matter as shown by the following mechanical analysis, which was supplied by the Soils Division of the Department.

TABLE I.

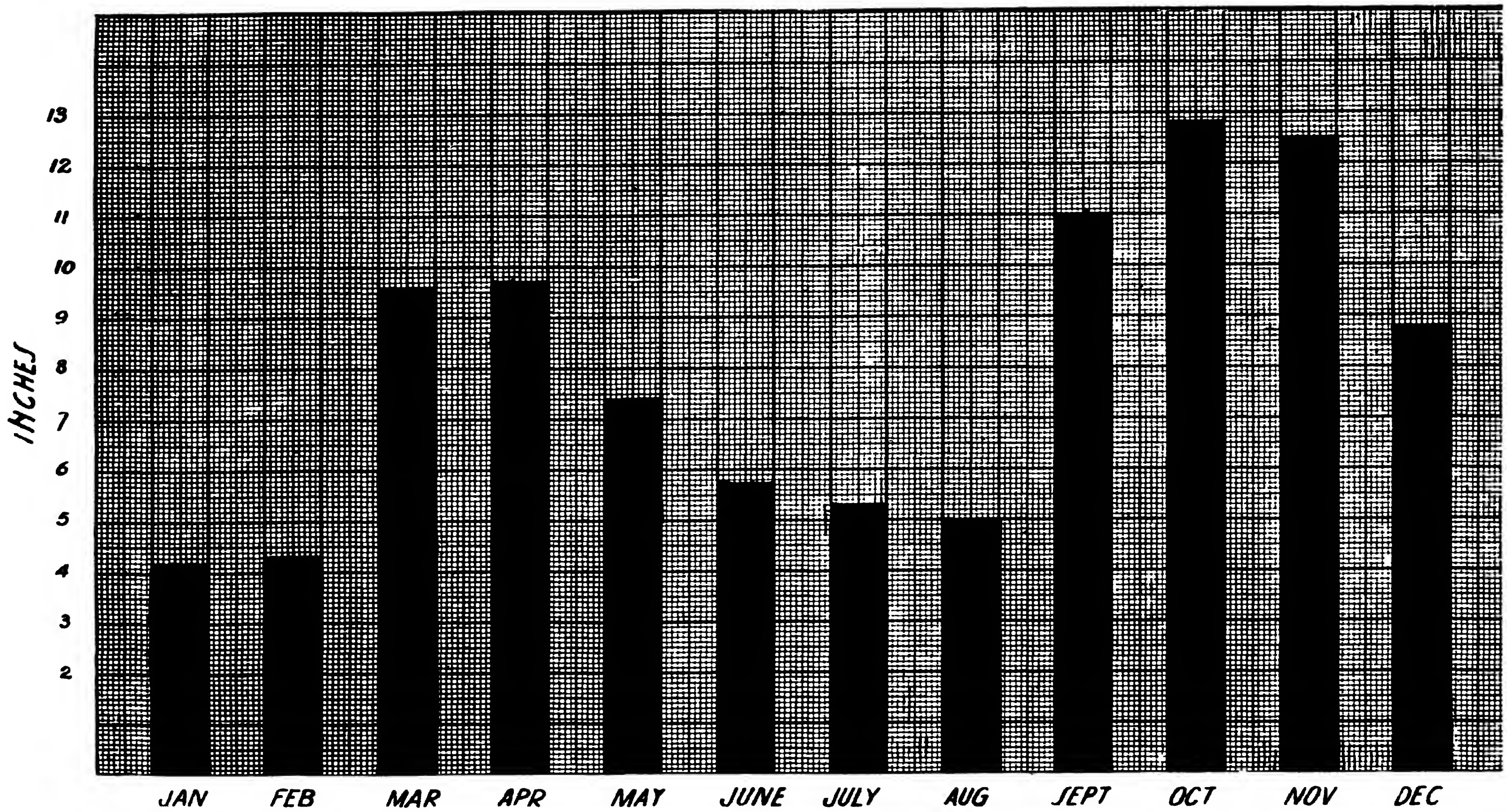
MECHANICAL ANALYSES OF FOUR SOIL SAMPLES FROM PARIT BUNTAR OFFICE COMPOUND.

Ref:	Depth.	Clay & Fine Silt.	Silt.	Sand.	PH.	Remarks.
R 244 T	to 1 ft.	32	36	24	4. 7/6.0	All these soils were rich in organic matter, the average loss on ignition being 20%.
R 244 Sa	2 ft.	58	19	11	4. 5/4.6	
R 244 Sb	3 ft.	53	18	12	3. 1/3.2	
R 244 Sc	4 ft.	42	23	12	2. 8/3.2	

The permanent water-table is never more than 4 feet below the surface of the soil and generally averages about 2½ feet only.

The rainfall is usually well distributed and averaged 97.80 inches per annum for the years 1922-1928. This annual average was, however, 9.09 inches above that for the past 41 years—the last 4 years having been exceptionally wet. The average monthly rainfall for any one month during the period never fell below 4 inches, and the months of March and April and from September to November were, as a rule, the wettest periods. These conditions were fairly typical of the coastal areas where good crop of coconuts were obtained.

Table II shows the average monthly precipitation over the last seven years.


INCHES
13
12
11
10
9
8
7
6
5
4
3
2
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC

Planting.

Six palms of each race were planted out in December 1921,of which five of each were selected for the purpose of our investigations: these have now been under close observation for the past seven years.

Germination to Flowering.

The nuts were sown on June 6th 1921. They germinated unevenly. The rates of germinations ranged in the 'yellows' from 35 to 79 days: the 'reds' from 21 to 92 days, and the 'greens' from 47 to 79 days. The date of germination assigned to each was that on which the tip of the young shoot became visible when busting its way through the husk. This variation in the rate of germination was expected as the nuts were not obtained, as far is known, from individual palms, so that there were, no doubt, differences in the ages of the fruits at the time of picking. On estates a period of four months from the time of sowing to germination is considered to be the limit for successful germination, so that these sprouted well within that time.

All of the palms were planted on December 11th, 1921, and subsequent growth was quite satisfactory. Among the 'yellows' and 'greens' the first to germinate was the first to flower, whilst of the 'reds', the third to germinate was the first to flower. From the time of planting to flowering nearly the same order was maintained.

The average period which elapsed from planting to flowering was for the 'yellows'—3 years, 86 days; the 'reds'—3 years, 105 days and the 'greens'—3 years, 263 days. The greens, however, flowered unevenly; the variation in the period between planting and flowering for the first time being considerable and included the earliest and the latest flowering palms of the whole series. Apparently they were not as pure, genetically, as the 'yellows' and 'reds'.

Table III shows the detailed results.

TABLE III.

No.	Race	Date Sown	Date Germinated	Difference in rates of germination	Date Planted	Date opening 1st spathe	Period from germination to 1st open spathe	Period from planting to 1st open spathe
1	Yellow	11.6.21	20.7.21	35 days to 79 days Av: 51 days	11.12.21	20.2.25	3 yrs. 215 days.	3 yrs. 71 days
2	,,	,,	29.8.21		,,	15.2.25	3 ,, 170 ,,	3 ,, 66 ,,
4	,,	,,	16.7.21		,,	7.3.25	3 ,, 234 ,,	3 ,, 86 ,,
5	,,	,,	30.7.21		,,	22.2.25	3 ,, 207 ,,	3 ,, 73 ,,
6	,,	,,	4.8.21		,,	30.3.25	3 ,, 238 ,,	3 ,, 109 ,,
1	Red	11.6.21	2.7.21	21 days to 92 days Av: 63 days.	11.12.21	29.4.25	3 ,, 301 ,,	3 ,, 139 ,,
2	,,	,,	7.8.21		,,	4.3.25	3 ,, 209 ,,	3 ,, 83 ,,
3	,,	,,	11.9.21		,,	14.5.25	3 ,, 245 ,,	3 ,, 154 ,,
5	,,	,,	29.8.21		,,	7.3.25	3 ,, 190 ,,	3 ,, 86 ,,
6	,,	,,	15.8.21		,,	15.2.25	3 ,, 184 ,,	3 ,, 66 ,,
1	Green	11.6.21	15.8.21	47 days to 79 days Av: 61 days	11.12.21	27.8.25	4 ,, 12 ,,	3 ,, 259 ,,
2	,,	,,	28.7.21		,,	20.9.24	3 ,, 54 ,,	2 ,, 282 ,,
3	,,	,,	6.8.21		,,	21.1.26	4 ,, 168 ,,	4 ,, 21 ,,
5	,,	,,	8.8.21		,,	16.4.26	4 ,, 251 ,,	4 ,, 126 ,,
6	,,	,,	29.8.21		,,	27.8.25	3 ,, 363 ,,	3 ,, 259 ,,

Spadix Production.

Spadix production was fairly well distributed throughout the seasons in each year: this was, no doubt, due to the fact that the water supply was ample for the requirements of the palms at all times. Each of the yellow and red palms started to flower in the early months of 1925. One green, however, commenced to flower in September, 1924, whilst two others did not flower until the early part of 1926. The 'yellows' produced on an average 18 spadices per annum: the 'reds' 15.5 only due to irregular spadix production of three of the palms in 1928. In this connection the cessation of spadix production for different periods in three of the red palms, although apparently quite healthy, is worthy of note. Red No. 2 was the most notable in this respect as it opened no spathes during two periods of 4 months and 5½ months respectively. The 'greens' produced 17 spadices per palm per annum the average being depressed somewhat by the late flowering of palm No. 4. The number of days between the opening of successive spathes varied for

(a)	Yellows	18.5 days	to	21.1 days.
(b)	Reds	19.3 ,,	,,	24.2 ,,
(c)	Greens	18.7 ,,	,,	23.1 ,,

The average for a normal dwarf race therefore being 20 days.

Early Spadices—Flowering and Fruiting.

The first spadix produced by dwarf palms bears few, if any, female flowers. In the palms under observation no female flowers were produced on the first spadix of the "yellows" and only two of them had female flowers on the second. The first spadices of the five palms set seven fruits only, five of which were borne on the 4th and 5th spadices of two palms. Two of the "reds" had 1 and 3 female flowers respectively, the rest none. No fruit was set on the first three spadices of these palms. Three of the "greens" bore female flowers on the 1st spadix, two of which formed fruits.

It might be mentioned that for all three types the number of branches per spadix, averaged 35. Also each spadix bends

TABLE IV.

Record of Spadix Production for the Years 1926, 1927 and 1928.

No.	Race.	1926. No. of spadices produced.	1926. Average No. of days between successive spadices.	1927. No. of spadices produced.	1927. Average No. of days between successive spadices.	1928. No. of spadices produced.	1928. Average No. of days between successive spadices.
1	Yellow	17	20.8	18	20.5	18	19.8
2	,,	19	19.0	19	19.7	18	19.2
4	,,	19	19.7	18	20.6	18	20.1
5	,,	19	18.5	18	20.3	18	20.2
6	,,	18	19.9	17	20.6	17	21.1
1	Red	16	21.6	17	21.3	(c) 14	24.1
2	,,(a)	12	19.3	15	22.6	(d) 8	22.0
3	,,	16	22.5	15	20.5	18	19.4
5	,,	16	24.2	17	22.4	(e) 16	22.5
6	,,	17	21.7	18	19.5	17	20.6
1	Green	17	21.6	16	22.5	17	21.1
2	,,	18	20.3	18	20.0	18	20.6
3	,,	17	20.6	17	21.3	19	19.4
5	,,(b)	12	23.1	17	21.3	17	21.5
6	,,	17	21.3	18	20.0	19	18.7

(a) Record for 9 months only. Spadix production ceased from 3.10.26 to 12.2.27.

(b) Record for $8\frac{1}{2}$ months only 1st spadix produced 16.4.26.

(c) No spadix 23.7.28 to 1.10.28.

(d) Record for $6\frac{1}{2}$ months only. No spadix from 18.6.28. to [end of year.

(e) No spadix 11.6.28 to 24.7.28.

TABLE V.

Female Flowers and Fruit borne on 1st Five Spadices.

No.	Race.	Spadix 1 No. of F flowers.	*No. of nuts at 2 mnths.	Spadix 2 No. of F flowers.	No. of nuts at 2 mnths.	Spadix 3 No. of F flowers.	No. of nuts at 2 mnths.	Spadix 4 No. of F flowers.	No. of nuts at 2 mnths.	Spadix 5 No. of F flowers.	No. of nuts at 2 mths.	Total No. of F flowers on 1st 5 spadices.	Total No. of fruits set on 1st five spadices.
1	Yellow	0	0	0	0	3	0	5	0	8	0	16	0
2	,,	0	0	0	0	7	0	7	0	12	0	26	0
4	,,	0	0	4	0	4	0	7	1	9	1	24	2
5	,,	0	0	5	1	6	0	12	0	10	4	33	5
6	,,	0	0	0	0	2	0	0	0	2	0	4	0
1	Red	0	0	0	0	1	0	3	1	5	1	9	2
2	,,	1	0	7	0	8	0	6	2	13	4	37	6
3	,,	0	0	0	0	1	0	3	1	6	2	10	3
5	,,	3	0	0	0	2	0	7	0	7	5	19	5
6	,,	0	0	7	0	6	0	10	3	13	3	36	6
1	Green	0	0	2	0	5	2	8	1	7	2	22	5
2	,,	0	0	4	0	4	0	3	0	5	0	16	0
3	,,	5	4	11	3	15	0	15	0	25	11	71	18
5	,,	1	0	4	3	6	3	5	4	6	3	22	13
6	,,	6	3	0	0	8	0	10	0	11	2	35	5

*Number of fruits remaining on spadices 2 months after flowering.

TABLE VI.

Record of Annual Production of Flowers and Fruit, 1925—1929.

Race.		1st Year—1925-26					2nd Year—1926-27.				3rd Year—1927-28.				4th Year—1928-29.			
			Spadices 1925.	Female Flowers.	No. of nuts at 2 Months.	Crop 1926.	Spadices 1926.	Female Flowers.	No. of nuts at 2 Months.	Crop 1927.	Spadices 1927	Female Flowers.	No. of nuts at 2 Months.	Crop 1928.	Spadices 1928.	Female Flowers.	No. of nuts at 2 months.	Crop estimated 1929
Y.	1	20.2.25 to 31.12.25	17	187	62	51	17	286	81	72	18	265	125	104	18	236	100	83
,,	2	15.2.25 to 31.12.25	18	256	67	42	19	409	118	105	19	370	141	127	18	290	140	134
,,	4	7.3.25 to 31.12.25	12	65	21	18	19	297	131	101	18	285	117	105	18	153	60	50
,,	5	22.2.25 to 31.12.25	13	98	45	19	19	236	94	79	18	273	119	109	18	136	65	55
,,	6	30.3.25 to 31.12.25	13	39	9	8	18	305	121	101	17	274	110	104	17	207	96	89
R.	1	29.4.25 to 31.12.25	9	18	6	2	16.	155	57	56	17	305	121	101	14	161	65	65
,,	2	4.3.25 to 31.12.25	13	163	56	46	12	192	72	60	15	225	116	107	8	139	37	34
,,	3	14.3.25 to 31.12.25	10	43	17	8	16	273	99	97	15	176	76	72	18	285	131	123
,,	5	7.3.25 to 31.12.25	10	52	23	17	16	221	99	87	17	239	103	91	16	275	132	125
,,	6	15.2.25 to 31.12.25	15	232	55	46	17	350	116	111	18	247	134	112	17	311	114	101
G.	1	27.8.25 to 31.12.25	7	42	12	12	17	447	88	74	16	384	120	89	17	411	93	88
,,	2	3.1.25 (i) to 31.12.25	16	320	83	48	18	412	86	74	18	370	102	84	18	350	95	85
,,	3	No flowers	0	...	...	...	*17	369	97	72	17	408	117	90	19	510	137	123
,,	5	do	0	...	...	...	†12	70	47	45	17	376	157	143	17	394	146	133
,,	6	27.8.25 to 31.12.25	8	64	3	6	17	467	88	73	18	414	73	68	19	453	105	83

(i) Produced 4 spadices with 11 flowers in 1924.

* Commenced flowering 21.1.26.

† Commenced flowering 16.4.26.

down in a direction opposite to that of the spiral formed by the expanding leaves, and all the spadices of each palm bend downwards in the same direction.

The details of flower and fruit production of the first five spadices of each palm are given in Table V, and the details of spadix, flower, and fruit production from commencement of flowering of each palm to the beginning of 1929 are given in Table VI.

The very uneven nature of the early flowering and fruiting of the palms particularly the "greens", is very noticeable. In the second year of fruiting they produce almost an average crop, and appear to reach full production about the third year. As the records are for a four year period only and for a small number of palms, it may be necessary to alter this statement when further annual records are obtained.

Table VII, compiled from Table VI, gives the total female flower and fruit production of each palm to the end of 1928, and Table VIII shows the averages. Among the points to be noted are—

(a) The 'greens' had the highest average number of female flower per spadix, namely 21.4: the 'yellows' had 13.6 and the 'reds' 10.6.

(b) The high percentage of female flowers which fail to set fruit.

(c) The low percentage of loss of fruit after 2 months from the time of flowering.

In regard to (b) and (c) the percentage of fruits to flowers remaining at 2 months, was for the 'yellows' 38.90%; 'reds', 53.2% and 'greens' 26.4%. Subsequent losses of fruit amounted to 5.7%, 5.4% and 4.2% only respectively.

The high percentage of infertile flowers was not due to insect injury, but, rather, it is thought to imperfect pollination or absence of viable pollen in unfavourable weather. On the other hand it is possible that the failure of development of a certain number of young fruits may be physiological.

TABLE VII.

Record of Total Flower and Fruit Production of Dwarf Coconut Palms from the time of 1st Flowering to Feb. 28th, 1929.

Race.	Palm No.	Total No. of Spadices.	Total No. of Female Flowers.	Total No. of Nuts at two Months.	Total No. Fruits which matured*	Remarks.
Yellow	1	69	974	368	310	
,,	2	74	1325	466	408	
,,	4	66	800	329	274	
,,	5	68	748	323	262	
,,	6	67	825	336	299	
Red	1	56	639	249	227	No spadix from 23.7.28 to 1.10.28
,,	2	48	719	281	247	No spadix from 3.10.26 to 12.2.27 do. 18.6.28 to 2.1.29
,,	3	59	777	323	300	
,,	5	59	787	357	320	No spadix from 11.6.28 to 24.7.28
,,	6	67	1140	419	370	
Green	1	57	1284	313	263	
,,	2	74	1452	366	291	
,,	3	53	1287	351	285	Started to flower 21.1.26
,,	5	46	840	350	321	Started to flower 16.4.26
,,	6	62	1398	275	230	
		925	13995	5106	4407	

* The 1929 crop was estimated on 28th February 1929 from the number of fruits then two months old and over on the spadices produced in 1928.

TABLE VIII.

Summary from Table VII.

Race	No. of palms	Totals of spadices	Totals of female flowers	Totals of fruits at 2 months	Totals of mature fruits
Yellow -	5	344	4,672	1,822	1,553
Red -	5	289	3,062	1,629	1,464
Green -	5	292	6,261	1,655	1,390
		925	13,995	5,106	4,407

Averages per Palm.

Race	Spadices.	Female flowers per spadix	Female flowers per palm.	Fruits 2 months	Mature fruits	Mature fruits per spadix
Yellow -	69	13.6	946	364	311	4.5
Red -	58	10.6	612	326	293	5.0
Green -	58	21.4	1,252	331	278	4.8

Percentages—Fruits to Female Flowers.

Race	Total female flowers	Fruits at two months %	Fruits at maturity %	Loss of fruits 2 months to maturity %
Yellow -	4,672	38.9	33.2	5.7
Red -	3,062	53.2	47.8	5.4
Green -	6,261	26.4	22.2	4.2

Fruit Production for 3 Years, 1926—1928.

The total numbers of ripe fruits obtained from the young palms over the period of three years, 1926—1928, are given below. The 'yellows' are shown to have given an average annual production of 94.5 fruits. The 'reds' 89.6 and the 'greens' 88.2. The average production of the 'reds' and the 'greens' was depressed by the erratic spadix production of R.2 in 1928 and the late flowering of G.5, although the latter was the heaviest cropper, notwithstanding its late start. As mentioned previously, full production may not have been reached in the period under review.

TABLE IX.

Fruit Production for 3 Years of Dwarf Palms. Planted Dec. 21st, 1921.

No.	Race.	1927 Total Fruit.	1928 Total Fruit.	1929 Total Fruit calculated from 2 months or over.	Grand Total.	Remarks.
1	Yellow	72	104	83	259	
2	,,	105	127	134	366	
4	,,	101	105	50	256	
5	,,	79	109	55	243	
6	,,	101	104	89	294	
1	Red	56	104	65	225	No spadix 23.7.28 to 1.10.28
2	,,	60	107	34	201	No spadix 3.10.26 to 12.2.27. 18.6.28 to 31.12.28.
3	,,	97	72	123	292	
5	,,	87	91	125	303	No spadix 11.6.28 to 2.7.28.
6	,,	111	112	101	324	
1	Green	74	89	88	251	Started to flower 21.1.26.
2	,,	74	84	85	243	
3	,,	72	90	123	285	
5	,,	45 (8½ mths. only)	143	133	321	Started to flower 16.4.26.
6	,,	73	68	83	224	
	Totals	1,207	1,509	1,371	4,087	

Average Production.

Race.	1927.	1928.	1929.	Annual average of 3 years.
Yellow	91.6	109.8	82.2	94.5
Red	82.2	97.2	89.6	89.6
Green	67.6	94.8	102.4	88.2
Mixed	80.5	100.6	91.4	91.27

Maturation Period of the Fruit.

It is not possible to ascertain definitely by external appearances when a fruit has reached, and not passed, the stage at which it is fully mature, so that the exact time from flowering to ripening can only be estimated. The fruits of all of the palms were picked when the husks had lost all of their distinctive colour and were quite brown and dry.

The Table X shows that, from the flowering to the date the fruits were picked, the period which elapsed was for the 'yellows' 12.4 months; 'reds' 13.4 months and 'greens' 13.1 months. The yellow fruits, therefore appear to reach maturity about one month earlier than the others. In this connection it is possible that the fruits may have reached maturity 3—4 weeks earlier than indicated by the periods above (flowering to picking).

TABLE X.

Maturation Period of Fruit in Months.

Race.	Palm No.	Fruits picked in 1926.	Fruits picked in 1927.	Remarks.
Yellow	1	12 months.	12 months.	Early ripening
,,	2	12.2	12.4	
,,	4	12.3	12.6	
,,	5	12.4	13.	
,,	6	12.3	12.8	
	average	12.2	12.5	
Red	1	12.6	12.8	Early ripening.
,,	2	13.4	13.1	
,,	3	13.3	13.8	
,,	5	13.5	13.7	
,,	6	14.1	13.6	
	average	13.4	13.4	
Green	1	13.4	13.3	
,,	2	13.3	13.2	
,,	3	13.2	13.3	
,,	5	12.0	12.8	Early ripening.
,,	6	13.4	13.0	
	average	13.1	13.1	

Pollination of the Flowers.

In our former article (loc. cit.) we stated that flowers were usually self-pollinated owing to the fact that the male and female phases of flowering of each spadix produced by these races of dwarf palms overlapped each other. Although numerous insects; more particularly bees, visit the male flowers to collect pollen and nectar, few appeared to be attracted by the female flowers situated near to the bases of the branchlets of the inflorescence, and following the results of experiments the opinion was expressed that pollination was effected chiefly by the wind.

As yet there is no detailed survey of the insect visitors to the flowers and the rôle they may play in scattering pollen

or facilitating self-pollination in other ways. Aldaba (2) showed that in the Philippines the amount of pollen carried by the wind, from cluster to cluster on the same tree, was probably enough to pollinate the female flowers of tall palms when the male phase of the flowering spadix overlapped the female phase of the previous spadix. As this could occur between different spadices on the same tree, it could be accomplished far more readily on a palm where there was an ample supply of pollen available on the same spadix.

Results of Germinating the Fruits.

The three races of dwarf palms are growing in three lines along three sides of the compound of the office at Parit Buntar. They are separated from each other in the lines at distances of 20 feet to 30 feet only, so that, if any appreciable amount of cross-pollination due to wind or insects occurred, it would be noticeable in their progeny.

A number of fruits of each was, therefore, collected and germinated and certain of them planted out at the Coconut Experiment Station, Klang.

The germination results of this second generation of nuts, totalling 642, showed that, in respect to the colour of the young shoot and subsequent growth, they were apparently true to the type of palm from which they were taken, with three exceptions which all occurred amongst the "greens". G.1 gave two red plants and G.6 one red plant. This was thought to be due to a mistake in labelling because the character for green plants is likely to be dominant to red—still cross-pollination was possible.

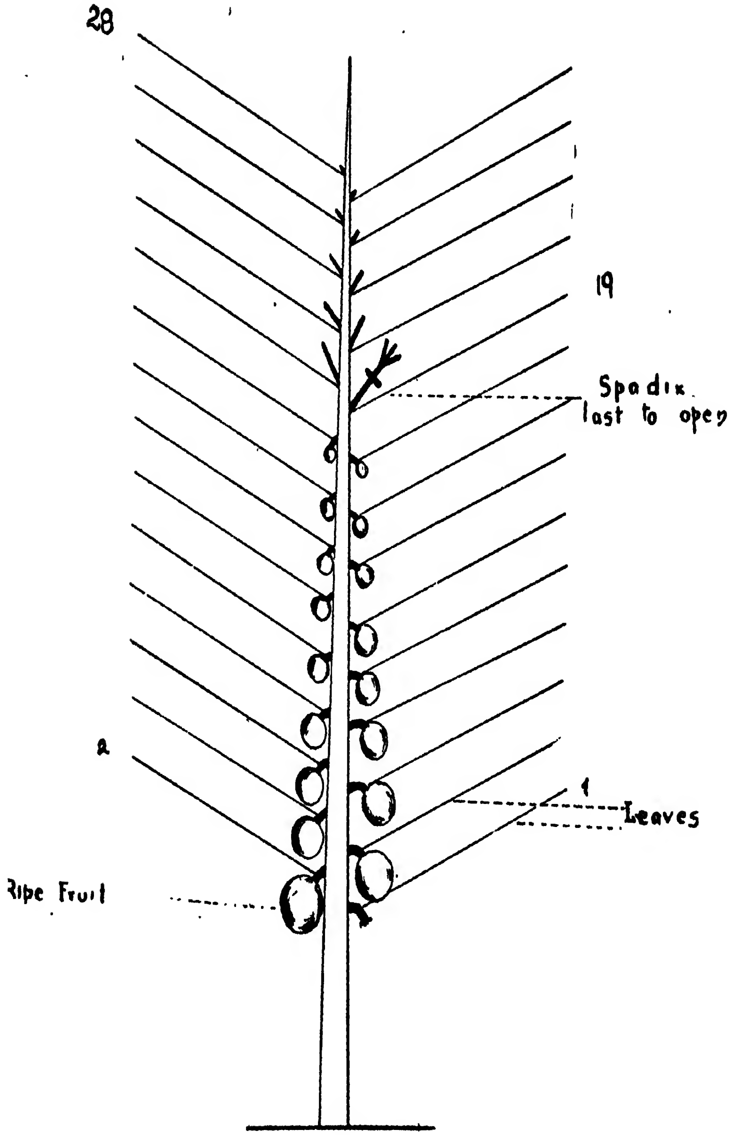
Twenty five plants from each palm were planted out from the germination beds and these are now nearing the flowering stage. To date no characters suggesting hybridization in this planting have been observed.

(2) Aldaba V.V.—Philippine Agriculturist, Dec. 1921. No. 5.

TABLE XI.

Germination Results of Fruit from Individual Palms.

Race.	Palm No.	No. of fruits germinat-ed.	Colour of shoot on germina-tion.	Race.	Palm No.	No. of fruits germinat-ed.	Colour of shoot on germina-tion.	Race.	Palm No.	No. of fruits germinat-ed.	Colour of shoot on germination.
Yellow	1	26	Yellow	Red	1	67	Red	Green	1	53	(51 green) (2 red.)
do	2	40	,,	do	2	30	,,	do	2	55	Green
do	4	45	,,	do	4	32	,,	do	3	47	,,
do	5	35	,,	do	5	58	,,	do	5	24	,,
do	6	40	,,	do	6	36	,,	do	6	54	(53 green) (1 red)
Total		186		Total		223		Total		233	



DIAGRAMMATIC SKETCH OF A
DWARF PALM IN BEARING

Leaves and Leaf Production.

The number of fully opened leaves of all ages, which forms the crown, may vary from 24 to 28 in palms up to seven years old. As a rule there are from 8 to 10 expanded leaves above a spathe which has newly opened.

As a spathe with its spadix is produced, normally, in the axil of each leaf once flowering starts, the rate of leaf-production can be calculated from the rate of opening of successive spathes. As one spathe follows another at intervals of about three weeks, 17 to 19 are produced each year, which number would also be the number of leaves which unfolded during that time.

A leaf may not fall for some weeks after the fruit on its spadix has ripened so that the time which elapses from unfolding to shedding varies but is approximately eighteen months. Should, however, disease attack the base of the stalk, it may fall earlier.

From the data which has now been given it is possible to make a diagrammatic sketch (see previous page) of a dwarf palm in bearing.

Crops.

During the past 7 or 8 years various estimates of crop returns from dwarf palms have given from 16 to 25 pikuls of copra per acre per annum as a fair yield for palms in full bearing under good average conditions. Few dwarf palm areas have yet reached the full producing stage, but it may be mentioned that one estate has recorded a yield of 19.29 pikuls of copra per acre from 100 acres of palms in their eighth year. This is the highest crop yet recorded for dwarf palms though other estates are obtaining crops approaching that figure, which has only rarely been touched by mature palms of the tall variety.

The fifteen dwarf palms, from which most of the data used in these "observations" are derived, have averaged 80.5, 100.6 and 91.4 fruits per annum in their 5th, 6th and 7th years respectively, from planting under good conditions though the soil in which they stand is distinctly heavy.

This rate of production of fruit gives an average per annum from 5th year from planting of 91 fruits per palm, and there seems to be no reason why this average should not be maintained and even improved. These palms are not growing under ordinary estate conditions, being subjected to rather

more shade from adjacent trees and hedges, but their average yield of fruits would give a calculated yield of some 15 pikuls of copra per acre from 5 year old palms which is undoubtedly useful compared with talls of the same age or even older.

Under ordinary estate conditions where 90—108 palms are planted to the acre, the commercial aspect of dwarf palms can be gauged from the average figures in Table XII, which are derived from actual returns collected from six estates and represent over 1,300 acres of dwarf palms.

TABLE XII.

PRODUCTION OF DWARFS AND TALLS COMPARED. THE FIGURES FOR DWARFS ARE AVERAGED FROM 6 ESTATES.

	Dwarfs.	Talls.
No. of palms planted per acre	90	48-55
Crop in pikuls of copra per acre 4th year	2.29	0
" " " " " " " 5th "	6.19	.5
" " " " " " " 6th "	7.52	2.00
" " " " " " " 7th "	9.24	4.00
" " " " " " " 8th "	11.68	6.00
From 10th year (estimated)	13.00	8.73
No. of nuts per pikul of copra (mainly yellow)	560	251
ditto - average of two estates (mixed dwarf palms)	482	251
ditto - green race only - estimated.	430	251
Weight in grammes of copra per nut (to nearest 10 grms.)	130	260
No. of nuts per palm per annum (conditions favourable)	90	56
Production of copra in lbs. per palm per annum (favourable conditions)	25	32
Production of copra per acre per annum in lbs. (favourable conditions)	2250	1600

From the above Table it can be seen that in addition to early maturity of the dwarf palms, they produce, under favourable conditions, some 25 lbs. of copra per palm per annum as compared with 32 lbs. from "talls". Hence, the advantage of dwarf palms over "talls" is that 90 palms can be planted to the acre as against only 50 "tall" palms and since 64 dwarf palms ($64 \times 25 = 1,600$ lbs.) can produce as much copra as 50 'talls', the production of the remaining 26 dwarf palms per acre is roughly a measure of the higher returns per acre of which dwarfs are capable compared with "talls" at the present time.

In collecting the above figures one estate had planted 108 palms to the acre, but all the others carried only ninety palms. As these figures are averages it must be understood therefore, that where conditions are good higher yields will be obtained, and conversely, uncongenial conditions or lack of attention will result in poorer crops. Thus, on the estates included in the above averages the production from 'dwarfs' in the eighth year ranged from 8.72 pikuls per acre to 19.29 pikuls. Dwarf palms are mature three or four years earlier than ordinary tall palms, and they produce profitable crops from their fifth year onwards as shown in Table XII.

In four out of the six estates the yellow type of dwarf was cultivated almost exclusively and hence the high figure for the number of nuts required to produce one pikul of copra. Two of the estates carried mixed populations of red, green and yellow palms and from these two estates 482 nuts only were required to make one pikul of copra. The dwarf plantations under observation are not yet mature enough to supply production figures beyond the 8-9th year from planting so that the average yield of 13.00 pikuls of copra per acre for mature dwarfs is estimated. Against this 8.734 pikuls of copra is quoted as the average production from tall palms and this was the actual average derived from figures collected from 30 well known estates, though for favourably situated estates the average exceeds 9.00 pikuls. The price obtained by estates for copra derived from dwarf palms does not differ materially from that paid for copra from tall palms, in fact most estates do not even separate them in preparing consignments for sale.

On most areas on which dwarf palms are planted the yellow type predominates excessively, being popular on account of its bright appearance. This fact is to be regretted since,

although it may yield a few more fruits per palm in its early years as is indicated in Table IX, it is now known that the yellow type on the average produces a smaller fruit yielding less copra per nut than either the red or the green type as shown in Table XIII. Moreover, the yellow type produces meat which appears to be more difficult to cure compared with that from the red and green types. Possibly high sugar content may account for this difficulty for the meat and the milk of the yellow dwarf are said to be sweeter than those from other dwarf types or than "talls".

Furthermore, the yellow type appears to be more readily subject to pest attacks and less resistant to poor conditions generally, than either the green or the red type. The green type is undoubtedly the hardiest as was anticipated several years ago on theoretical grounds.

TABLE XIII.

ESTATE PRODUCTION—THE NUMBER OF NUTS REQUIRED TO PRODUCE 1 PIKUL (133 LBS.) OF COPRA.

Race.	Estate.	No of nuts.	Copra in pikuls.	No. of nuts per pikul.
Green	A	1,500	4.115	462
,,	B	500	1.035	483
,,	C	1,422	3.760	405
	Totals	3,422	8.910	Average = 407
Red	A	996	2.225	448
,,	B	100	.20	500
,,	C	120	.26	461
	Totals	1,216	2.685	Average = 453
Yellow	A	1,482	3.040	488
,,	B	1,000	1.760	568
,,	C	1,493	3.028	493
	Totals	3,975	7.828	Average = 508

The figures in the above Table were supplied by three estates A, B, and C which, at the request of the writers, kindly carried out carefully supervised tests of the Comparative amounts of copra obtainable from nuts of the three different colour types.

The Table shows that the number of nuts required to produce 1 pikul of copra for the green type averaged 407 nuts, for the red type 453 nuts and for the yellow type, 508 nuts. These figures would probably be increased by 5% in each case under ordinary estate routine as they are derived from an insufficiently large number of nuts to ensure accuracy, but they definitely indicate the approximate proportions which exist between the three colour types as copra producers. The figures also show that the average sizes of the nuts of each type vary considerably on the three estates; this is, no doubt, mainly due to varying environmental conditions and to different degrees of cultivation.

At the same time it must be mentioned that inherent variation in size of nuts is marked. Thus dwarf palm E.B. No. 139 (Green 3) has consistently produced nuts some 20% larger than those of any of the other palms under observation by the writers. The result of an examination of bulked samples of small numbers of nuts collected from various sources is shown in Table XIV. The figures in this Table, though only derived from a very small number of nuts and therefore subject to a wide margin of error (probably not less than 10%) roughly confirm the proportionate copra producing abilities already indicated in Table XIII.

Thus, for the green type the average weight of copra produced per nut was found to be 143 grammes, for the red type 139 grammes and for the yellow type 129 grammes, and by calculation these figures would give 422, 434 and 468 nuts respectively to one pikul of copra for green, red and yellow types.

TABLE XIV.

Analyses of Dwarf Fruits.

Race.	Average weight in grammes per nut.			% Moisture in copra.	% Oil on dry basis.
	Nut	Meat	Copra		
Green Lot A – 11 nuts	480	248	134	9.01	65.78
„ „ B – 12 „	510	231	131	6.70	64.32
„ „ C – 20 „	560	253	135	—	—
„ „ D – 20 „	710	337	162	—	—
Averages	584	243	143	7.80	65.02
Red Lot A – 11 nuts	620	275	140	8.31	64.10
„ „ B – 9 „	460	236	136	8.54	68 88
„ „ C – 24 „	550	260	134	8.34	65.69
„ „ D – 19 „	640	278	148	—	—
Averages	557	243	139	8.37	65.94
Yellow Lot A – 12 nuts	420	201	123	10.01	64.91
„ „ B – 12 „	590	252	126	8.61	66.22
„ „ C – 24 „	470	231	120	—	—
„ „ D – 22 „	550	280	143	5.95	63.70
Averages	511	245	129	7.74	64.78

Table XIV also shows the average moisture content of the various copra samples and the oil content expressed as a percentage of the dry weight of copra. The average oil content percentages of the three races are approximately the same and coincide with the average oil content of copra derived from the ordinary tall varieties of palms which fluctuates normally from 64—66% in this country.

In the Table, the "D" lots all came from the same source and it is noticeable that these samples in each case show a higher copra content per nut than the other lots in each class. This is probably due to better environmental condi-

tions, particularly as regards soil, and shows how improved conditions tend to produce larger nuts. The moisture and oil percentages were determined by officers of the Chemical Division of the Department of Agriculture to whom the writers are indebted.

Economic Life of the Dwarf Palms.

Doubt is sometimes expressed regarding the length of the economic life of dwarf palms as compared with the ordinary tall types and it has often been assumed that it is limited to 17—20 years. This supposition is based on statements made by Banjarese cultivators who have been accustomed to grow the dwarf palms in the Krian District of Perak State where for 9 months every year the land is inundated for padi cultivation and even in the brief dry spells of weather between the padi season the water table never drops more than two feet below the surface of the soil. Dwarf palms at least 35 years old and still bearing quite good crops can be seen as isolated trees, usually planted for ornamental purposes, in various parts of the country and though no plantations of dwarfs of sufficient age exist to guide opinion there seems no reason why they should not produce profitably for at least 35 years under good estate management. Observations have idicated that where general conditions for growth are good, the dwarf palm gives excellent returns but where conditions are only fair or rather difficult, they are not so satisfactory. The green type, as has been shown, produces the best individual fruits from the viewpoint of copra production and approximately equals the other dwarf types in the number of fruits matured annually.

The green dwarf, under fair average conditions, is capable of producing some 25 lbs. of copra per palm per annum which is nearly as much as the average tall palm produces, (about 27-28 lbs.), whereas double the number of dwarf palms can be planted per acre of land hence the green dwarf should prove a lucrative investment.

Other Advantages of Planting Pure Races of Dwarf Coconuts.

The planting of pure races of early fruiting dwarf coconuts which grew and yielded well under local conditions

offers certain advantages over the tall forms at the present time, among these being—

(a) Similar growth and fruiting characters.
(b) Each palm is genetically a high-yielder.
(c) The palms mature evenly.
(d) The probable production of copra of less variable quality.

The above remarks would apply equally well to the tall types, but as far as is known there is none as pure genetically as the local dwarfs we have described, with the result that in all plantations there are bad, medium and good yielding palms.

In our paper (3) on variation in tall coconuts we have shown (a) that the co-efficient of variability in fruit production is as much as 37% of the mean production, (b) that 19% of the palms on an average estate are not profitable, (c) that 13% of the average population produces 22% of the crop and (d) that high-yielders remain high-yielders and poor-yielders remain poor-yielders.

Many of the tall palms we have studied have produced an average of 85 nuts and over per annum (records cover a period of eight years) so that apart from the question of early maturity of the dwarfs, if tall forms could be obtained, which would breed true, as the dwarfs do, to the character or characters for high yield, then these would prove superior to the dwarfs in yield of copra per acre, and perhaps in other ways.

This aspect of coconut production is being dealt with by the Botanical Division of the Department in the Coconut Experiment Station where breeding experiments with both tall and dwarf races are in progress.

Toddy from Dwarf Palms.

Dwarf palms would appear to be useful from the view point of "toddy" production since the young palms usually flower 3-4 or even more years earlier than tall palms and approximately twice as many palms can be planted to the

(3) Variation in Coconuts. H. W. Jack and W. N. Sands. Malayan Agricultural Journal. Vol. XV. No. 11 (1927).

acre. Moreover, the spadices of dwarf palms are produced in more rapid succession and are more easily accessible than those of 'talls' though more spadices have to be tapped to produce the same amount of liquid as compared with tall palms. Tamil coolies prefer "toddy" derived from dwarf palms because it is sweeter and more palatable than that produced by talls.

The yield of toddy per day from young 'dwarfs' varies from half a pint up to about six pints, but a fair average yield per palm would be about one and a half pints daily. Tall palms would average about double this quantity, but the rate of collection would be slower and more arduous. The chief factors in favour of dwarf palms in this connection are the ease of collection of liquid, the earlier returns as compared with tall palms, and the popularity of the liquid on account of its sweetness.

Summary.

1. The germination, growth, flowering and fruiting characters of the three common races of dwarf palms are described.

2. The cropping abilities of the 'dwarfs' are shown in detail for 15 palms which have been under strict observation since germination.

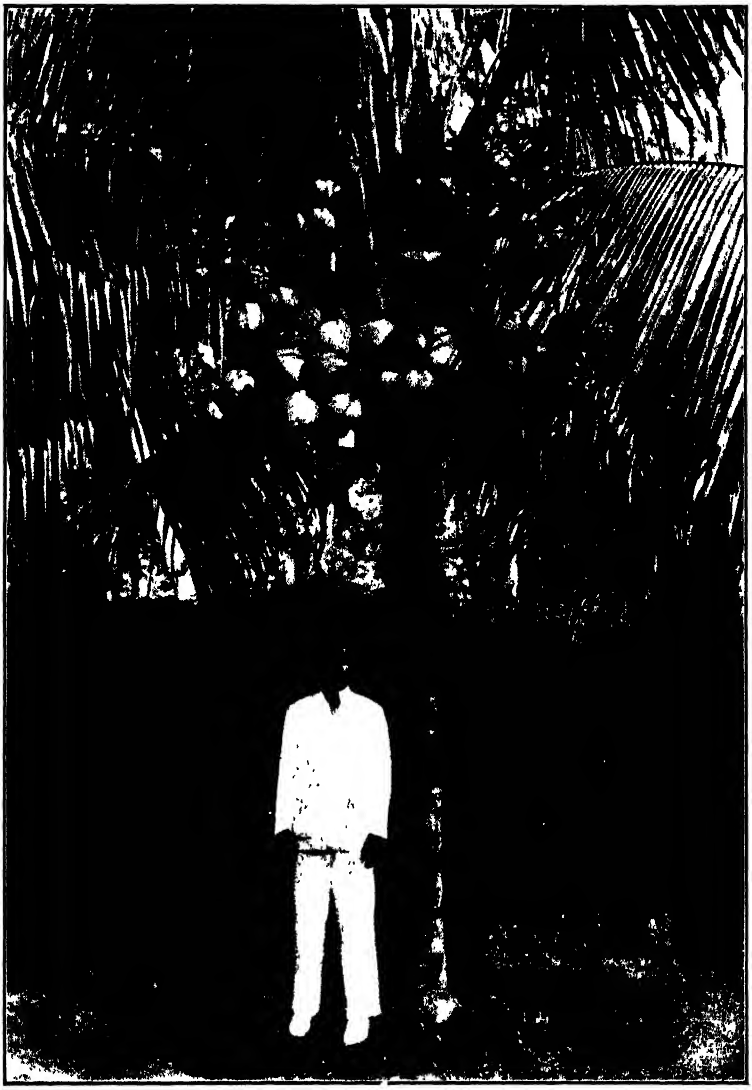
3. Crop returns from dwarf areas of six commercial estates are averaged and compared with average returns from commercial areas of "talls".

4. Variation in average copra producing ability between the three common dwarf types is outlined.

5. It is shown that, given suitable conditions and fair treatment, the dwarf palm (particularly the green race) is a sound commercial proposition.

Received for publication 9th April, 1927.

Dwarf Yellow—4 years old.



Dwarf Yellow—7 years old.

Dwarf Red—4 years old.

Dwarf Red—7 years old.

Dwarf Green—4 years old.

Dwarf Green—7 years old.

Piqui-a Fruit Oils.

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Ag. Agricultural Chemist.

INTRODUCTORY.

Piqui-a, *Caryocar villosum*, a large tree indigenous to Brazil is a comparatively recent introduction to Malaya, the first seeds having been imported about nine years ago for planting under estate conditions.

The trees have made good growth, being now about 50 feet high and with a spread of branches approximately equal to the height.

The trees flower between the months of March and June. the fruits ripening during October and November.

Piqui-a fruit, like oil palm fruit, contains two oils, one present in the pericarp of the seed, the other in the kernel.

DESCRIPTION OF FRUIT.

The sub-drupaceous fruits, which may contain as many as three or four seeds, are globular in shape, measure 4—4½ inches in cross section and approximate in size to large oranges. When there are two or more seeds present the fruit tends to assume an oblong shape. The outer layer of the pericarp, which is approximately ½ inch in thickness, is light brown in colour and smooth in texture.

It is interesting to note that this outer layer contains a relatively high percentage of a tannin of a pyrogallol type, amounting to approximately 9.0 per cent on the fresh material, equivalent to 33 per cent on a moisture-free basis.

The seeds, which vary from 2¼ to 2½ inches in length, are flattened at the base and rounded at the apex. The inner layer of the pericarp surrounding each seed and approximately ⅛—¼ inch thick is yellow in colour and contains oil. The material composing this layer darkens on exposure to air.

The shell of the nut varies in thickness from approximately ¼ inch on the sides to ½ an inch at the apex, the shell itself being composed of two layers, an outer layer full of brittle spicules and a hard thin inner layer.

The kernel is about 2 inches long and ¾ inch thick and is covered with a dark brown testa. The flesh of the kernel is white.

Composition of Fruit.

The following table shows the approximate composition of the fresh fruit, the inner layer of pericarp and the kernel:—

Fresh fruit.

Average weight of fruit.	300 grammes.
	per cent.
Proportion of outer layer of pericarp ...	73.9
Proportion of inner layer of pericarp ...	13.1
Proportion of shell ...	11.3
Proportion of fresh kernel ...	1.7
Proportion of pericarp oil on fresh fruit	6.2
Proportion of kernel oil on fresh fruit ...	0.8

Inner layer of pericarp.

Moisture ...	34.4
Oil (petroleum ether extract) ...	47.4
Residue (by difference) ...	18.2
Oil (calculated on moisture-free basis) ...	72.3

Kernel.

Moisture ..	26.6
Oil (chloroform extract) ..	45.1
Residue (by difference) ...	28.3
Oil (calculated on moisture-free basis) ...	61.4

Characteristics of Oils.

Owing to the small number of fruits available it was not possible to prepare sufficient quantities of either of the oils

for the determination of the more important analytical constants by treating the material in the small laboratory hand-press. Both the pericarp and kernels were therefore solvent extracted, the former with petroleum ether and the latter with chloroform.

The pericarp oil is reddish-orange in colour and has an agreeable odour. When cooled a few degrees below the normal atmospheric temperature the oil solidifies to a fat which is somewhat lighter in colour.

The kernel oil is yellowish in colour and semi-solid at ordinary temperature. The oil is odourless when cold, but develops a slightly unpleasant odour on heating.

The table on page 169 gives the details of the physical and chemical characteristics of the oils, average figures for palm oil being added for comparison with those for the pericarp oil. Figures showing the constants of an oil from another species of *Caryocar*, referred to in "Chemical Technology and Analysis of Oils, Fats and Waxes", Lewkowitsch and Warburton, Vol. II, page 567 are also added for comparison with those for the kernel oil. No figures appear to have been published previously for any pericarp oil from a *Caryocar* species.

It is interesting to note that this oil from *Caryocar tomentosum*, known as Sawarri or Souari fat, is sometimes referred to as "Pekeanut" oil and as regards its constants they will be seen to be similar to those for the kernel oil from the present species under examination.

Remarks and Conclusions.

The results of analysis show that the constants of the pericarp oil agree closely with those for palm oil and it appears probable therefore that piqui-a pericarp oil can be used for similar purposes. The oil is easily bleached and high quality oil would therefore be suitable as a basis in the preparation of edible fats.

A series of experiments showed however that in the preparation of high quality oil it would be necessary to treat the ripe fruits without delay owing to the presence of an enzyme causing free fatty acids to develop on storage.

TABLE SHOWING CHARACTERISTICS OF PIQUI-A FRUIT OILS.

	Piqui-a fruit pericarp oil.	Palm oil.	Piqui-a fruit kernel oil.	Oil from *Caryocar tomentosum.*
Specific gravity at 99°C (water at 15°C = 1) ...	0.8622	0.859	0.8617	0.8981[1].
Melting point (complete fusion)	27°-28°C	27°-42.5°C (varies according to acidity)	31°-32°C	29.5°-35.5°C
Saponification value ...	204.9	199-201	202.9	199.51
Iodine value (Wijs) ...	46.6	53-58	52	49.5
Acidity (Oleic acid per cent) ...	1.1		0.2	
Unsaponifiable (per cent) ...	0.7		1.3	
Fatty Acids.				
Solidifying point (Titer value)	48°C	40°-47°C		46°-47°C
Mean molecular weight ...	274	273		272.8
Iodine value (Wijs) ...	48.5	53		51.5

[1] Specific gravity at 40°C

The kernel oil, similar to the oil from *Caryocar tomentosun*, could also be used for edible purposes. In this connection it is interesting to note that the kernels of this species and the allied species, *Caryocar nuciferum*, are highly esteemed as dessert nuts in West Indies and South America.

In conclusion the writer desires to express his thanks to the Directors of the Irai Co., Ltd., for permission to publish the results of the investigation.

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Oil from Hydnocarpus Anthelmintica.

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and

GUNN LAY TEIK,
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INTRODUCTORY.

A consignment of fresh seeds of *Hydnocarpus anthelmintica*, Pierre was received recently from the Government Experimental Plantation, Serdang where this tree is being cultivated.

As is well known the question of the cultivation of this tree has attracted much attention recently on account of the application which the oil from the seeds finds in the treatment of leprosy.

A full description regarding the introduction of *Hydnocarpus anthelmintica* to Malaya, its habit of growth under local conditions and the methods of cultivation employed at Serdang has already been published in this Journal, compare "Chaulmoogra and Hydnocarpus Oils", Vol. XV, 1927 No. 4, page 114, the article being based on information published during the previous year in the Bulletin of Miscellaneous Information issued by the Royal Botanic Gardens, Kew.

In this connection it may be mentioned that both *Hydnocarpus Wightiana*, Blume and *Taraktogenos Kurzii*, the seeds from which yield oils similar to that from *Hydnocarpus anthelmintica*, are also under cultivation at Serdang.

From a chemical point of view the fatty acids present in the greater proportions in these oils, namely chaulmoogric and hydnocarpic acids, are unique among naturally-occuring fatty acids on account of their cyclic structure and optical activity.

Further, since from a medical point of view better results have been obtained in certain cases with preparations containing hydnocarpic acid derivatives it is essential to determine as early as possible whether this acid is present in the oil from the *H. anthelmintica* now under cultivation at Serdang. Such an investigation will, however, only be possible when larger supplies of the seed are available.

Although the amount of seed available was insufficient to permit of a detailed examination of the fatty acids it is considered advisable to publish the preliminary results in view of the world-wide interest now being taken as regards both chaulmoogra and hydnocarpus oils as a cure for leprosy.

Oil Content of Seed.

The seeds were brown in colour, ¾ - 1 inch long and ½ - ¾ inch broad. A hard shell encloses the kernel, which is covered with a thin reddish-brown skin. The flesh of the kernel is white.

The results of analysis are shown in the following table.

Seed.	grammes.
Average weight of seed ...	2.42
Average weight of kernel ...	0.77
	per cent.
Proportion of shell ...	68.2
Proportion of kernel ...	31.8
Kernel.	
Moisture (loss at 100°C) ...	26.5
Oil (petroleum ether extract) ...	42.5
Residue (by difference) ...	31.0
Oil (calculated on moisture-free basis) ...	57.8
Oil (calculated on fresh seed) ...	13.5

Analytical Constants of Oil.

The kernels were crushed by passing between rollers, but owing to the moist state of the kernels it was necessary to dry

the resultant meal before pressing in the small laboratory hand-press. No difficulty was experienced as regards the expression of the oil. The crude oil was filtered to remove traces of moisture and matter in suspension.

The oil was pale yellow in colour and had a pleasant odour.

The average results of duplicate determinations for the more important analytical constants are shown in the following table.

Oil.

Specific gravity at 30°C (water at 15°C=1)	... 0.9429
Refractive index at 27°C	... 1.4726
Saponification value	... 206.4
Iodine value (Wijs)	... 81.5
Acid value	... 1.0
Optical rotation (chloroform solution)	... +47.9° at 29°C

Fatty Acids.

Solidifying point (Titer value)	... 39.1°C
Mean molecular weight	... 260.5
Neutralisation value	... 215.3
Iodine value (Wijs)	... 84.8
Optical rotation (chloroform solution)	... +49.7° at 28.8°C

Remarks and Conclusions.

The low oil content of the fresh seed, 13.5 per cent, is due to the relatively high moisture content of the fresh kernel. With a normal moisture content of 10 per cent for the kernel the oil content of the seed would increase to approximately 16 per cent, a figure slightly below that recorded for this seed from other sources.

The trees from which the seed was collected are, however, only in the early fruiting stages and it is possible therefore that with an increase in age of the tree there may be a slight increase in the oil content of the kernel.

The figures for the chemical and physical constants of the oil and fatty acids agree favourably with those published by other workers.

A feature of the oil is the low acid value. In this connection attention is drawn to the importance of treating the kernels without delay if oil of good quality is to be recovered. Under estate conditions there should be no difficulty as regards this procedure but if seeds are left lying about before collection and stored without being dried there will be a considerable increase in the acidity of the oil.

As mentioned previously however it will only be possible to judge the full value of the oil from the medical point of view when some idea has been obtained of the relative proportions of the fatty acids present in the oil.

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General Consideration on a Soil Survey of Malaya.

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Most progressive countries during the last three decades have undertaken some form of soil survey with the idea of facilitating agricultural practice by ascertaining the distribution of different kinds of soil and, by utilising previous experience, of predicting the parts of the country most likely to be suited to various crops and the soil treatments likely to give the best results with each crop.

It will readily be realised that the actual nature of the soil at any particular spot is not the only factor involved, climate and topography playing very large parts from the agricultural standpoint. It is an easy, although a time-consuming task, to describe the soils of any area in terms of some particular character, such as physical composition (proportions of particles of different sizes) or chemical composition but trouble is at once encountered when an attempt is made to group soils, i.e. to classify them. What basis should be chosen, and should it deal with intrinsic properties or with genetic relationships? It is agreed that no one stratum of the soil nor character can entirely be relied on, and a selection must be made from a number of characters.

The earlier surveys, especially those in the United States, started with classification based on geological origin, as it is reasonable to suppose that soils formed from similar rocks should be similar in many respects. As the surveys extended

* In charge Division of Soils and Plant Physiology.

however it was found that these relationships did not hold, similar parent material producing widely different soils under different climatic conditions. Recently the very active Russian workers have classified soils on the basis of climate and have shown that, subject to certain limitations, similar climates tend to produce similar soils irrespective of geological origin.

Until recently no systematic soil work had been carried out in Malaya and when a definite Soils Division was constituted the most pressing task appeared to be that of classification; especially in view of the impracticability within any reasonable time of a detailed soil survey of the whole area of Malaya. If a satisfactory classification of soils on easily accessible areas could be devised it might then be possible approximately to predict the soil characteristics of larger inaccessible areas, due regard being paid to modifications due to topography.

In spite of the failure of geological classifications in the U.S.A. it seemed not improbable that when dealing with the relatively very small area of Malaya over which the climatic conditions (from the soil-forming standpoint) are uniform, such a basis might be useful, as very considerable areas of Malaya have been dealt with by the Geological Survey and the results given on the "Geological Sketch Map of Malaya". To test this a detailed survey was carried out over a limited and accessible area. The results of physical analyses of the samples collected are described in the succeeding paper.

It is believed that the results of this preliminary survey show that the inland soil (i.e. those formed *in situ* or nearly so) can broadly be grouped on a geological basis, climatic factors having, as anticipated, acted uniformly.

To verify the suggested grouping, it will be necessary to carry out analyses on different areas throughout the country. At present we have outside the surveyed areas only a limited number of samples taken for other purposes. These as far as they go, confirm our conclusions. It has been decided that this work of checking must await the completion of detailed work on the difficult problem of the coastal alluvial soils, and it is thought that the results already obtained, which might be of some help to planters, should be published, with full reservation of liberty to change the suggested classification should further work indicate the desirability of such a step.

In view of the limited scope of the succeeding article reference to chemical analyses and the place of our soils in a world-scheme of classification has been omitted. These and other points will be taken up later when a comprehensive discussion of Malayan soils is published.

Assuming that the classification put forward is correct we have next to enquire in what way the work may benefit agriculturists. We are immediately faced with a difficulty already set forth by the writer* viz. that there exists no fund of previous experience with any inland dry land crop except rubber. This at once limits us to the simplest deductions, those based on mechanical composition. Information regarding manuring and soil treatment generally will only be available after considerable experimental field work with different crops on the various soil types.

With regard to mechanical composition we learn from the tables and figures in the succeeding article that of the *high level soils* (i.e. soils above valley level):--

1. The "Raub" soils are far more uniform in texture than the other two groups, which show considerable variation in the clay/sand ratio. Once topography is known the texture of any area of "Raub" soil may therefore be assumed with but little sampling.

2. Owing to the fairly general occurrence of gravel and stones, soils of the "Raub" and "Granite" groups have a more open texture than the "quartzites" which even when sandy "pack" badly on exposure.

3. Erosion is always serious but an amount of erosion which will deteriorate a "quartzite" with its deep and rather uniform profile may absolutely ruin a "Granite" or "Raub" by washing away the highly differentiated top soil and leaving only a stony subsoil or indeed bare rock. Cases of such damage have actually occurred.

Of the *low level soils* (valley soils) it emerges that the "quartzites" are far more likely to exhibit undesirable features such as shales, black soil etc. than are the other two, and therefore need careful prospecting.

* Annual Report for 1927. This Journal XVI, p. 170 '28.

In conclusion the writer desires to emphasise the provisional nature of the classification adopted, and also to point out that none of the soils dealt with are "rich" in the sense of giving on analysis high figures for nutrients even in the virgin state. There are one or two geological formations such as the "Pahang Volcanic Series" which when near the surface may produce "rich" soils, but they have not yet been surveyed, and in any case are of limited distribution, compared to the three groups discussed here. No soil in the tropics should however be condemned on the grounds of "poverty" alone, rubber furnishing an excellent example of a crop which flourishes exceedingly on extremely "poor" soils.

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Preliminary Results of a Soil Survey in Selangor.

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In the previous paper it was suggested that in spite of the failure of a classification of soils on a purely geological basis in the U.S.A. owing to the climatic conditions, yet in this country where climatic conditions are more or less uniform, such a basis might be useful and it was with this idea in view that a detailed survey over a restricted area was carried out.

The factor determining the area over which the survey was made, was, in the first place accessibility, this being regarded as of paramount importance for rapidity of work. The second point was that the area should pass through the main geological formations.

For these reasons the area chosen was one stretching through Cheras and Klang to the sea, thus including the four main geological types and further including the Experimental Plantation of Serdang and Ayer Hitam Forest Reserve. the former being examined completely in detail and the latter in detail near the road frontage.

The four main geological types mentioned above are:—

(a) Limestones and calcareous shales, phyllites without sandy beds which may be referred to collectively as the Raub series.

(b) Quartzites, including sandstones, shales and certain phyllites which may be altered to schists near granite.

(c) Granite.

(d) Coast alluvium.

The vast majority of the area of Malaya which has been geologically surveyed has been shewn to consist of one of these formations. There are three additional geological types with which it is not proposed to deal here as the areas which

they cover are comparatively small and are not to be encountered in the country over which the soil survey was carried out.

The oldest formation is the Limestones etc (a). They were deposited on the sea floor in Palaeozoic times far from land, beyond the reach of sediment brought down to the sea by rivers.

Later shallow water conditions set in and alluvium was brought down by the rivers which in the course of time under pressure became altered to quartzites and sandstones. Where this alluvium was in contact with limestone calcareous shales were formed.

At a later date, the granite and allied rocks which now form the backbone of the peninsula, forced their way up through the earlier formations.

Lastly the coastal alluvium, which although its age runs into millions of years is geologically modern has been gradually formed by the erosions of the older formations, the sediments of which have been deposited on the sea floor by the rivers.

This briefly and in a very elementary way represents, in the main, the formation of these four types. Calcium has been gradually leached out of the calcareous shales until at the present time the overlying soils seem to be little or no richer in calcium than any other soils.

High level alluviums have been formed in parts by the erosion of granites and quartzites and have apparently been deposited in many cases over limestone. Inland alluvium is still being formed at the present day and is discussed further in connection with soils as found in the survey.

Survey Results.

Sampling was carried out on the soil overlying each of the geological formations, detailed at first, the distance apart of sampling increasing as information was obtained about the different types of soils.

It may now be stated that as a result of this survey it is concluded, at least as far as the area suveyed is concerned that there is a distinct soil type for each of the four formations mentioned above.

The soil overlying the alluvium however is not dealt with here, as the whole of the coastal alluvium is likely to prove much more complex than the inland formations and requires separate consideration. The soils overlying the other three formations will be referred to in the rest of this article as

(a) Raub family.

(b) Quartzites.

(c) Granites.

The reason for so naming these soils will be made clear below, though it must be stated that these names are purely tentative, and they may have to undergo certain modifications as further information becomes available.

The general features observed were :—

(a) THE RAUB FAMILY.

The soils under this heading may be divided into two parts "soils above plain level" and "plain soils", or more shortly "high level" and "low level" soils. The former might be further subdivided into "hill top soils" (including very steep slopes) and "general above plain level".

(i) *High Level.*

The distinctive features of the soils above plain level is the appearance of hard "laterite"* beds at a depth of from eighteen to thirty inches generally, but which may be right at the surface where land has been subjected to heavy wash (hill tops and steep slopes) or may, where conditions have caused an accumulation of soil on top, be some feet below the surface. They are in fact the soils which are commonly known locally as laterite soils, a name which it is better to avoid as a soil description owing to the controversy as to the correct use of the term.

These beds are always deep enough to resist much penetration by a sampling tool in contra distinction to quartzites, where "laterite" may occur but usually only as a thin layer.

It seems probable that these beds are a layer of accumulation of ferrugenous material leached out from the soils above.

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*Laterite is here used in its local popular sense rather than as a strictly scientific term.

The overlying soil is always of a redder colour than the quartzites except where swamp and waterlogged conditions have existed, when it may be reduced to a pale yellow.

The soil above the laterite bed usually shews a good crumb structure and does not have that tendency to "pack" exhibited by the quartzite. It is usual to find over 45 per cent of clay in the surface soil, in fact there is less variation in the clay of this type than in any of the others as will be seen from the correlation tables which are discussed below.

In the lower layers the analysis of soil passing the 3 mm. sieve is deceptive as out of the total original soil as much as 75 per cent stones may be found by the time a depth of two and a half to three feet is reached. This is also brought out in the tables. The total sand at any depth is generally not above 25 to 30 per cent, the bulk of the coarse fractions being classed as gravel.

(ii) *Low Level.*

These soils would appear to be of the nature of a high level alluvium, probably overlying a limestone floor. No soils of this type occur in the survey area, but an excellent example may be seen on the road from Setapak towards Klang Gates and for the first few miles along Batu Road from Kuala Lumpur to Batu. The distinguishing features of the areas on which these soils occur may be said to be their flat open nature. The soils are usually whitish yellow in colour occasionally mottled and show a fairly open texture and crumb structure. They frequently "feel heavier" than their mechanical analyses would lead one to suppose which may be accounted for by the necessarily artificial nature of their drainage. They do not appear shaly as the quartzite valley soils neither do they shew the darkening which is such a distinctive feature of the latter.

(b) QUARTZITE.

The quartzite soils also may be divided into two groups (i) Valley Quartzites and (ii) General Quartzites, but owing to a much more intimate relationship holding between them than in the case of the two groups of the Raub family, they are here considered as a whole.

This is probably the soil most commonly met with agriculturally in this country, though its actual area is considerably less than the granite, which covers the main range

of the peninsula; quartzite on the West side of the main range covers large tracts of undulating land which have been agriculturally exploited.

Its colour is usually a brownish orange. This colour does not differ greatly from that of granite, though on an average it is probably rather "brighter". The soils around the Agricultural Department are typical of the quartzite. The mechanical composition seems to show much more variation than the granite, the clay for instance on undulating ground may vary from 15-45 per cent and generally speaking the soils contain a fair quantity of silt. This type of soil has a tendency to "pack" and its crumb structure is considerably less than that of Granite or Laterite.

Owing to the softer nature of the parent material there seems a tendency for the quartzite valleys to be much broader than the granites and for heavy shaly formation to occur there. One of the peculiar features of this heavy shaly formation is the frequent inclusion of organic matter in a very finely divided state, which on extremely heavy clays (fine fractions of the order of 70 per cent and over) is often present as free carbon, the soils being jet black when they are wet. Generally such dead black soils are modified at the surface and appear as a brownish black. These black soils seem to have definitely toxic effects on plant life due probably to ferrous iron compounds including iron pyrites. It is suggested that these (black) soils are formed by swamp conditions and from observations made at Serdang it seems likely that they generally ensue at what may be described as the centre of a swamp drainage area. Often a curiously impervious sandy bed is encountered in broad quartzite valleys and plains at a depth varying from four to six feet.

On the other hand as in the cases of the granites, where quartzite valleys do approximate to the gorge type, the soil is usually more sandy than the surrounding land due no doubt to the clay being swirled away and deposited in more open areas during heavy rain.

A still further feature is the frequent occurrence, at depths which may vary between eighteen inches and over six feet, of a thin layer of " laterite" often accompanied or sometimes entirely replaced by quartz chips up to an inch across. This layer is generally not very compact and of only an inch or so in thickness and is fairly easily gone through. It would

seem to be a layer of accumulation between the upper weathered rock in the form of soil and the schist formations below. Leaching of the soil above appears to have freed much ferrugenous material which has accumulated at the layer of separation of the schists and soil, with the formation of "laterite." This has been mentioned above under Raub family soils.

(c) GRANITE.

A soil which may vary from a pale yellow to a red in colour and generally approximately to a bright yellow. On undulating land it is a friable soil composed of sands and clay with little or no silt. A typical analysis of such a soil would be clay 40—50, silt 0—5, sand and gravel 55—45. In cases where broad valleys are filled with soil from hillsides there is a considerable increase in the silt content and a diminution of sand but in cases where valleys between hills approximate to gorges the reverse is the case there being a considerable decrease in the clay and increase in the sand.

The valley clay soils are friable. At the junction of granite with neighbouring formations the soils may present an unusual appearance, soils on the Kajang—Puchong road for example near the Raub family junction shewed kaolin; on the other hand on the Klang Road there is a sharp change from normal granite soils to normal quartzite.

CORRELATION.

The general mechanical relationships have been brought out by means of the correlation tables and graphs given at the end of this article.

From these tables it will be observed that:—

(i) Exclusive of hill tops and very steep slopes and above plain level the Raub family soils shew a great evenness in the percentage of clay at the surface, all of them shewing clay in the 46—60 group (Table I) while the sand and gravel for the most part lies in 31—45 group. From Table II it will be seen that fifty per cent of these soils contain up to 15% stones at the surface.

From Table I again it will be seen that the clay content is reduced some 15% at a depth of 30" for about eighty per

cent of the soils and even as much as 30% for the remaining twenty per cent. From Table II it will be noticed that none of these soils contain less than 16% stones at a depth of 30″. Fifty per cent of them contain 16—30 at this depth, twenty per cent contain 31—45% and thirty per cent of them contain over 60 per cent of stones.

These stones all bright red in colour and which may be loosely described as laterite are sufficient in themselves to differentiate the soils from any others.

(ii) In the quartzite valley soils the clay is evenly distributed for the most part through a considerable range of percentages (eighty-six per cent lying between 16 and 60%) the sand also shewing a wide range (seventy three per cent evenly distributed from 31% of sand upwards). At a depth of 30″ there is no change in the clay distribution but somewhat of an increase in the percentage of soils shewing sand 46—60%.

(iii) In general quartzite soils, over fifty per cent of them have a clay content of 31—45 at the surface and that nearly sixty per cent of them have a sand content of 46—60. There is little change in this composition at 30″.

From Table II it will be seen that some ten per cent of quartzite soils contain up to 15% of stones at a depth of 30″ and eight per cent contain even more.

(iv) Over forty four per cent of the granite soils have a clay content at the surface of 31—45 and forty per cent have a sand content of 46—60. At a depth of 30″ forty per cent have the above clay content, with a tendency for the clay content to increase, while fifty-eight per cent have a sand content between 16—30%.

(v) The figures indicated above are not in themselves sufficient to differentiate the granites and quartzites, but an examination of gravel contents shows marked differences between them. From Table III it will be seen that whereas only half the granites shew a gravel content 0—15, ninety eight per cent of the quartzites fall within these limits and at a depth of 30″ rather less than half the granites and eighty

seven per cent of the quartzites shew a gravel content of less than fifteen per cent.

The difference is even more strikingly shewn in Table IV when it will be seen that whereas only sixteen per cent. of the granites have a gravel content of less than 4%, eighty-five per cent of the quartzites fall within this category

The larger gravel content met with in the granite soils seems to account for the marked open structure which they shew.

Agreement of the Soil Types as outlined above with the Geological Boundaries.

It has been stated above that the three soil types (a) Raub family, (b) Quartzite, (c) Granite sketched above are found overlying the respective geological formations (a), (b) and (c). The question immediately arises in the mind that assuming a certain type of soil described as granite, is found overlying a granite geological formation, will this type of soil disappear and the "laterite" type appear as one passes over the geological junction from the granite to the "Raub Series". This may be answered in the affirmative as far as the area under survey is concerned. In many places the cleavage is sharp, as on the railway from Kajang to Kuala Lumpur, where in a cutting between the 257th and 258th mile it is possible to see the geological change over from granite to Raub series and by sampling to confirm the change over of soils. In other places it is impossible owing to the deep swamp nature of the soil to find the change over. In cases, the soil change over may not agree precisely with the geological change over owing to topographical conditions. For instance suppose that the junction of a granite and quartzite formation occurs on a hill side, the granite being situated higher up the hill. Then one would naturally expect to find a certain amount of granite soil on the quartzite side of the junction.

The indications as set forth in this paper are of course empirical and are founded on the area actually surveyed. It may be that "spot" examination in other parts of the peninsula may cause a certain amount of modification of what has been written above, though casual soil samples which have been received in connection with other problems from Johore, Pahang and Negri Sembilan confirm the above conclusions.

A striking confirmation of soil type agreeing with geological formations must have been noticed by anyone travelling along the Port Dickson road which from Seremban to Port Dickson lies entirely over the "Raub Series" geological formations (coloured blue on the geological sketch Map). The untrained eye may not be able to recognise the features which indicate the geology (which may be assumed to be correct) but one can hardly fail to recognise the distinctive soil features indicated above under the heading Raub family, whereever the land is undulating or silt pitted.

Particular thanks are due to Mr. J. B. Scrivenor, the Director of Geological Surveys for the valuable help he has given in this connection.

A geological sketch map of Malaya is appended, taken from the Geological Department's progress map. It may be subject to slight modifications but as a whole it represents the geology of the country as surveyed up to the present time. It is hoped that in conjunction with the above article it may be of some assistance in providing a broad differentiation between the main inland soils.

Received for publication 14th May, 1929.

TABLE I.

PERCENTAGES SOILS SHOWING VARYING % OF CLAYS AND SANDS WITH GRAVEL AT SURFACE AND AT 2 FT. 6 INS.

Clay % / Sands and Gravel %		Under 15		16—30		31—45		46—60		61 and over	
Soil		At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″
Granite	C ...	0	20	34	20	46	40	24	30	6	10
	S ...	8	8	4	58	24	20	40	10	24	4
Raub Family Excluding Hill Tops (high level)	C* ...	0	0	0	20	0	80	100	0	0	0
	S ...	0	50	0	50	80	0	20	0	0	0
Raub Family (Low level)	C* ...	12	0	75	75	13	25	0	0	0	0
	S ...	0	0	13	12	25	25	25	63	37	0
Quartzite Valley	C ...	5	4	28	29	33	36	25	22	9	9
	S ...	13	9	14	14	25	18	23	35	25	24
Quartzite General	C ...	4	0	26	28	54	53	16	19	0	0
	S ...	0	0	2	4	14	13	58	62	26	21

* Table based on analysis of some 20 soils only. Visual inspection confirms these figures.

TABLE II.

Percentages Soils shewing varying % of Stones at Surface and at 2 ft. 6 ins. (on original soil).

Stones %	0-15		16-30		31-45		46.60		61 and over	
Soil	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″
Granite ...	0	16	0	0	0	0	0	0	0	0
Raub Family Excluding Hill Tops, but all above plain level.	50	0	0	50	0	20	0	0	0	30
Quartzites ...	0	10	0	6	0	2	0	0	0	0

TABLE III.

PERCENTAGES SOILS SHOWING VARYING % COARSE SAND AND GRAVEL AT SURFACE AND AT 2 FT. 6 INS.

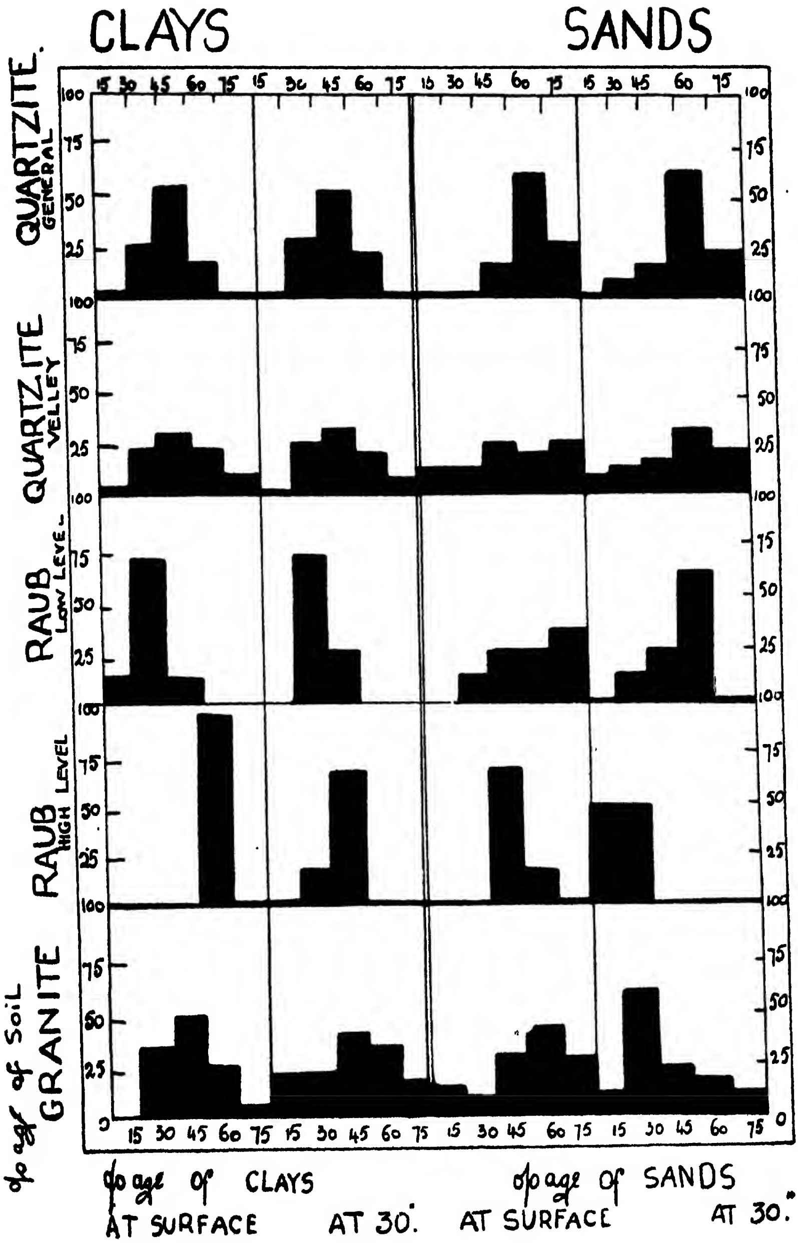
Coarse Sand % Gravel %		0—15		16-30		31-45		46-60		61 and over.	
Soil		At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″
Granite	C. S. ...	24	24	60	60	16	16	0	0	0	0
	Gravel ...	48	44	48	48	4	8	0	0	0	0
Quartzite	C. S. ...	5	10	52	54	31	28	8	6	4	2
	Gravel ...	98	87	2	5	0	8	0	0	0	0

TABLE IV.

PERCENTAGES SOILS SHOWING VARYING % GRAVEL AT SURFACE AND AT 2 FT. 6 INS.

Gravel %	0—4		5—8		9—16		17—24		24 and over	
Soil	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″	At Surface	At 30″
Granite	16	12	16	20	28	24	32	20	8	24
Quartzite	85	65	5	8	10	14	0	2	0	11

TABLE I.



CLAYS
SANDS
QUARTZITE GENERAL
QUARTZITE VELLEY
RAUB LOW LEVEL
RAUB HIGH LEVEL
GRANITE
%age of Soil
%age of CLAYS
AT SURFACE
AT 30".
%age of SANDS
AT SURFACE
AT 30".

TABLE II.

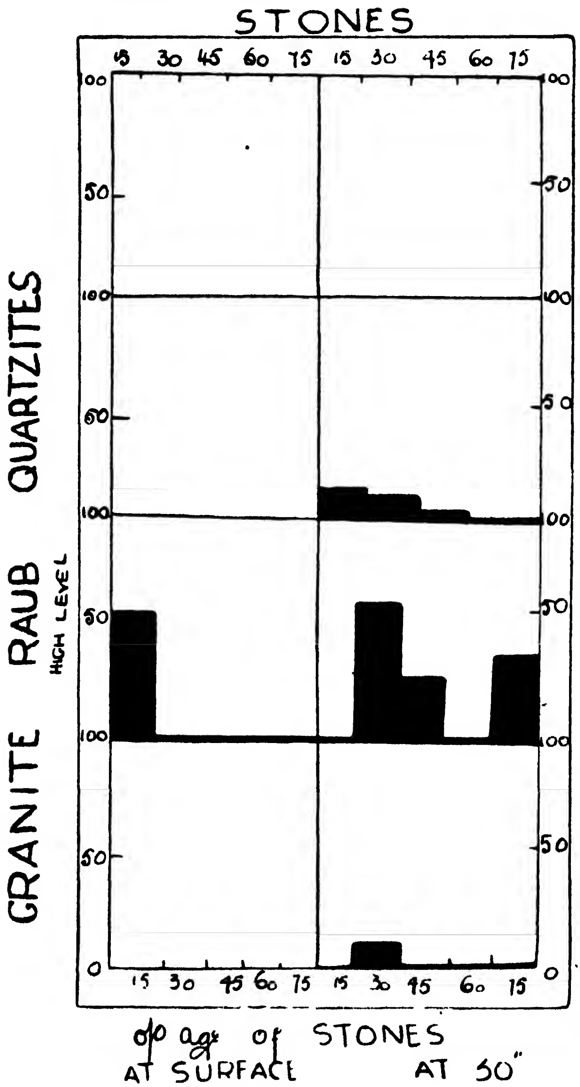

STONES
15 30 45 60 75 15 30 45 60 75
100
50
QUARTZITES
RAUB
HIGH LEVEL
GRANITE
0
%age of STONES
AT SURFACE
AT 50"

TABLE III.

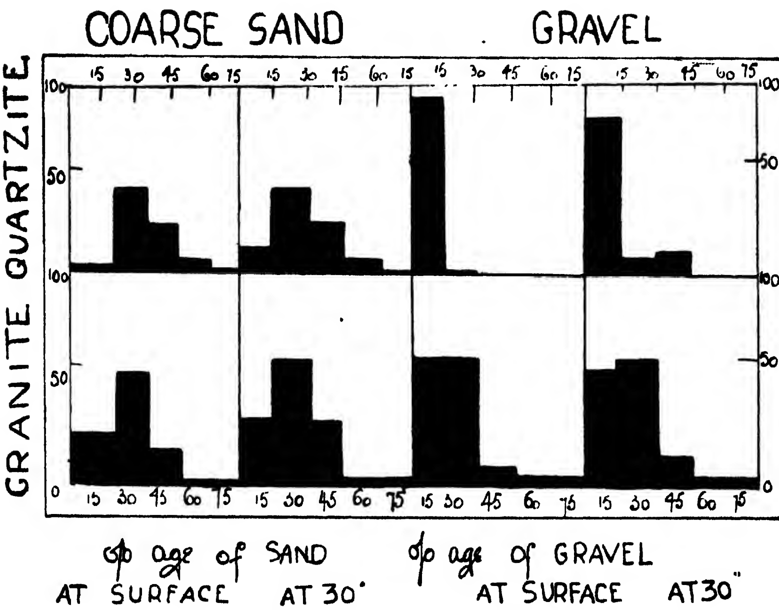
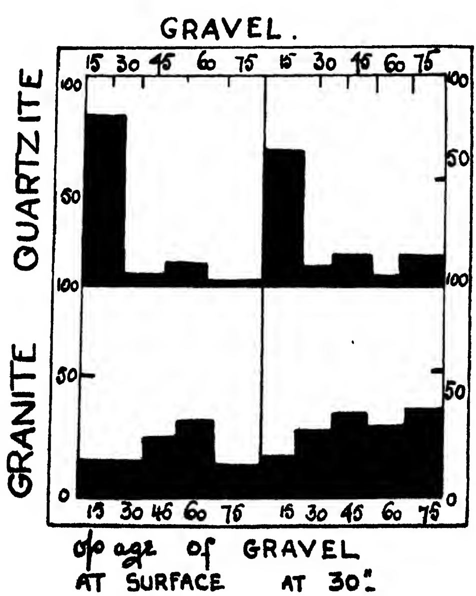


TABLE IV.



Percolation Experiments.

I. NITRIFICATION AND EFFECT OF COVER PLANTS

BY

W. N. C. BELGRAVE,

Plant Physiologist.

Considerable inequalities having been found in certain nitrification experiments, it was decided to set up a series of percolation experiments to test nitrogen losses as indices of nitrification. The same lay-out was then used for observations of nitrogen losses under covers. These observations are still in progress, but the results obtained up to date may be of some interest and are accordingly published.

LAY-OUT OF EXPERIMENTS.

Cylindrical glazed earthenware pots 17″ high and 11½″ internal diameter holding 25—28 kilos (56—62 lbs.) of moist soil were used. Drainage water was led through tubulures into covered receptacles.

The pots were filled with earth at field moisture (about 20%) taken at a depth of 1—6″ and after the treatments set forth in Table I, were left bare and fully exposed to the weather. Analyses were made whenever 800 ccs. or more of percolate had collected. The year 1928 was marked by prolonged dry spells which accounts for the relative infrequency of analytical results. Soil "A" was a sandy "quartzite"* soil from a slope which had been clean weeded under rubber and oil palm for many years. It had suffered considerably from erosion and the clay was highly deflocculated, as a result the percolates were frequently very cloudy and required filtration. Like all soils of this group it is very prone to

* For an explanation of these terms vide M. A. J. this issue page 181 et seq.

"pack" badly. The pH of 1:2 suspension with quinhydrone was 4.9, N as nitrate less than 1 part per million, and lime requirement (by calcium acetate) 1.6 tons per acre (CaO). Soil "B" was what is called locally a "laterite" soil—one of the "Raub family, high level" soils.* It had been under "lallang" (*Imperata arundinaçea*) for an indefinite period, was of fair crumb structure and always gave clear percolates. pH = 4.4; N as NO_3 4 p.p.m., lime requirement 2.2 tons per acre.

TABLE 1.

The differences in volume of percolate collected from the different pots illustrate the extreme difficulty of securing uniform packing. These differences do not however obscure certain facts:—

(1) That nitrification of all fertilisers proceeded normally.

(2) That there was a considerable increase of nitrate losses from soil left fallow even though no nitrogenous manures had been added.

(3) That the acidity (indicated by a *low* pH value) of percolates increased with increasing nitrate content.

TABLE II.

It has frequently been demonstrated that the growth of plants reduces drainage losses to a very great extent. It must however be remembered that where cover plants with superficial roots are growing with main crops which may be deeper rooted—the drainage losses found under the conditions of our experiment are, as far as nitrates are concerned, the plant food of the main crop plant, since nitrates are formed only in surface soil. In view of the normally low concentrations of nitrates in our soil, it is clear that rapid absorption by the cover might tend towards nitrogen starvation of the main crop. It was therefore decided to try the effect of cover plants. For the first cover a grass crop was chosen, both because of vigorous growth and also because

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* vide M.A.J. this issue page 181 et seq.

grasses are known to have a deleterious effect on many fruit trees.

The results show clearly:—

(a) That the nitrate in percolates from grassed plots was reduced practically to zero.

(b) That there was a decrease in acidity coinciding with a fall of nitrates.

TABLE III.

The next step was to plant a cover other than grass, for this purpose *Calapogonium mucunoides* was selected. This plant gave irregular growth, but again especially on soil "B" the results show a great reduction of nitrates in the percolate wherever good growth was made.

The all-round reduction is due to the heavy leaching experienced by the soils in the very heavy March-April rains of this year.

CONCLUSIONS.

Fallow and covers.

It is impossible on the results of these experiments by themselves to give definite advice for use in the field—but two points appear to emerge:—

(a) That land left fallow will suffer considerable losses by leaching downwards of the product of nitrification. This confirms the abundant experience of other countries.

(b) That the distance of covers from the main crop especially when that crop is in early stages should carefully be considered, lest the cover starve the main crop of nitrogen. This applies particularly to the growth of permanent covers.

Acidity and nitrate development.

As far as the relationship between acidity and nitrate content goes, the results of tables I and II strongly support the view previously expressed by the writer that the dis-

crepancy between pH values observed on suspensions and in clear extracts of many of our soils is due to the very low concentration of the soil solutions—which do not contain sufficient quantities of anions to carry hydrogen ions out of the field of action of the soil particles. The results in table III however are puzzling, since the only differences in treatment of the bare pots in this experiment was that during dry weather the pots were watered. This would suggest the rather incredible hypothesis that nitric acid formed in nitrification could be neutralised by the small quantities of bases in the soil only if the amount of moisture exceeded a certain critical value. Further observations on this point are in progress and will be reported in due course.

Summary.

Observations are reported on the nitrogen losses from soils under covers, bare and enriched by nitrogenous fertilisers.

Received for publication 16th May, 1929.

TABLE I.

Soil into pots on 29.11.27, percolate up to 14.12.27 bulked. Treatments applied on 16.12.27.

Soil "A."

Pot No.		30/12/27	6/2/28	9/2	22/3	6/4	13/4	18/5	Average N. as mgs. per litre.
1. Lime = $\frac{1}{4}$ ton per acre -	pH percolate	6.2	5.9	4.2	4.8	4.2	4.7	4.2	
	Vol. percolate (litres)	2.0	1.8	4.0	1.0	1.3	2.75	.8	
	N. parts per million as NO_3	1	trace	7.0	28	27	40	31	18
2. Lime = $\frac{3}{4}$ ton -	do.	6.2	6.4	4.2	4.5	4.2	4.3	42	
		2	2.5	4.0	1.15	.9	2.75	.70	
		0.4	trace	7	50	33	40	29	18
3. Lime = 3 tons -	do.	5.8	5.8	4.4	4.2	4.2	4.1	4.2	
		2.00	1.5	3.4	1.3	1.2	2.7	1.2	
		0.6	2	5	50	40	60	30	25
4. Control -	do.	6.2	5.6	4.0	4.2	4.2	4.2		
		2.0	.4	1.2	1.0	.6	1.6	lost	
		0.7	spoilt	7	27	27	40		18

"Soil A."—(Contd.)

5.	Grass = 20 tons.	do.	6.2 2.0 0.2	4.2 2.6 3	4.1 4.1 4	4.7 1.0 33	4.4 1.6 40	4.0 2.7 60	4.2 1.5 33	21
6.	Ammonium sulphate = 4 cwts.	do.	6.2 2.0 0.2	6.4 1.5 2	4.5 3.4 10	4.0 1.5 50	4.0 1.6 52	4.0 3.4 60	4.2 1.4 36	29
7.	Urea = 2 cwts.	do.	6.2 2.0 0.6	4.6 1.1 trace	4.1 3.4 14	4.0 1.3 50	4.2 1.3 40	4.0 3.1 80	4.2 8. 31	34
8.	Ca. Cyanamide = 4 cwts.	do.	6.2 2.0 0.7	6.2 1.0 trace	4.1 2.6 6.8	4.5 1.4 50	4.4 1.7 47	4.2 2.7 60	4.2 1.0 62	3[illegible]
9.	Ammonium phosphate = 2 cwts.	do.	6.1 2.0 0.2	6.5 2.9 trace	4.0 3.4 8.3	4.2 1.7 50	4.4 1.6 33	4.0 2.8 54	4.2 1.3 31	22
10.	Potassium nitrate = 6 cwts.	do.	5.0 2.0 1.5	4.2 1.8 12	4.0 3.5 25	4.0 1.6 125	4.2 2.3 40	4.2 2.5 50	4.0 1.2 37	39

Bulked percolate on 14.12.27 pH = 6.2, N as NO_3 1.4 p.p.m.

TABLE I.

Soil "B."

Pot No.		30/12/27	6/2/28	9/2	22/3	6/4	13/4	18/5	Average N. as mgs. per litre.
1. Lime = ¼ ton	pH percolate	All percolates pH 4.0; 2000 cc N as NO_3 60 p.p.m.	4.2	4.2	4.2	4.2	4.0	4.2	
per acre -	Vol. percolate (litres)		1.5	3.0	9	1.3	2.7	1.0	
	N. parts per million as NO_3		45	60	50	55	50	30	51
2. Lime = ¾ ton -	do.		4.0	4.2	4.1	4.2	4.2	4.2	
			1.6	1.3	2.3	2.2	2.7	1.6	
			70	40	85	55	50	30	57
3. Lime = 3 tons -	do.		4.0	4.0	4.1	4.2	4.2	4.2	
			1.9	3.4	8	2.8	2.1	6	
			50	35	90	100	80	30	69
4. Control -	do.		4.2	4.4	4.2	4.0	4.0	4.2	
			1.8	3.2	7	1.0	2.7	8	
			50	30	35	55	60	60	47
5. Grass = 20 tons	do.		4.4	4.4	4.2	4.2	4.2	4.2	
			4.0	3.6	7	2.2	3.4	7	
			45	45	80	55	50	40	49

"*Soil B.*"—(*Contd.*)

6.	Ammonium sulphate = 4 cwts.	do.	All percolate pH 4.0 : > 2000 cc N as NO_3 60 p.p.m.	4.4 1.9 50	4.0 3.4 40	4.2 9 85	4.2 1.4 140	4.2 2.7 100	4.2 7 40	69
7.	Urea = 2 cwts.	do.		4.0 4.8 55	4.2 4.2 40	4.2 2.5 85	4.2 2.8 100	4.2 3.4 80	4.2 2.2 65	66
8.	Ca. Cyanamide = 4 cwts.	do.		4.0 2.6 50	4.2 3.2 80	4.2 6 170	4.2 1.8 100	4.2 2.9 80	4.2 1.3 60	79
9.	Ammonium phosphate = 2 cwts.	do.		4.3 1.5 60	4.2 1.9 40	4.0 2.7 80	4.2 .9 100	4.2 2.8 80	4.2 1.2 35	65
10.	Potassium nitrate = 6 cwts.	do.		4.0 1.9 65	4.2 3.2 80	4.1 2.7 60	4.2 1.9 55	4.2 2.6 60	4.2 1.2 35	63

Bulked percolate of 14.12.27 pH=4.7, N as NO_3 20 p.p.m.

TABLE II.

HISTORY AS IN TABLE I. GRASS PLANTED IN ALTERNATE POTS 14.6.28.

Soil "A."

Pot No.		12/10	15/10	23/10	9/11	23/11	3/12
1. Bare	pH percolate	4.5	4.5	5.7	4.7	4.2	4.5
	N as NO_3 p.p.m.	8	12	16	16	10	28
2. Grass planted.	do	6.2	6.2	6.2	6.2	6.2	6.2
		0	0	trace	0.8	0	0
3. Bare	do	4.4	4.5	4.4	4.4	4.2	4.4
		13	18	18	16	12	12
4. Grass planted.	do	6.0	6.2	6.2	6.4	6.2	6.2
		0	0	2	trace	0	1
5. Grass planted.	do	6.2	6.2	6.2	6.2	6.2	6.2
		1	0	0	trace	0	1
6. Bare	do	4.2	4.2	4.4	4.2	4.2	4.4
		8	28	26	24	8	20
7. Bare	do	4.4	4.4	4.2	4.2	4.2	4.4
		12	38	28	28	20	20
8. Grass planted.	do.	6.2	6.2	6.2	6.2	6.2	6.2
		0	0	trace	0	0	0.5
9. Grass planted.	do	6.4	6.2	6.2	6.2	6.2	6.2
		0	0	1	3	2	0
10. Bare	do	4.2	4.2	4.4	4.0	4.0	6.2
		8	12	28	28	8	28

TABLE II.

Soil "B."

Pot No.		12/10	15/10	23/10	9/11	28/11	3/12
1. Grass planted.	pH percolate	6.2	6.2	6.2	6.2	6.2	6.2
	N as NO_3 p.p.m.	0	0	0	0	0	0
2. Bare	do	4.2					
		30	40	20	30	30	30
3. Grass planted.	do	6.0					
		trace	0	0	trace	0	trace
4. Bare	do	4.2					
		45	40	25	55	35	30
5. Grass planted.	do	4.0					
		40	50	20	55	35	25
6. Bare	do	4.2					
		30	50	40	55	55	35
7. Grass planted.	do	6.2					
		trace	0	trace	0	trace	trace
8. Grass planted.	do	6.0					
		0	trace	trace	trace	trace	
9. Bare	do	4.2					
		45	55	40	30	35	30
10. Grass planted.	do	6.0					
		trace	0	trace	trace	0	

TABLE III.

History as in Tables I and II. Grass removed from all except one pot (each soil) on 14.11.28. Soil heavily leached for 3 days till NO_3 in percolate was nearly zero. Calapogonium planted on 20.11.28, and all pots watered daily with 300 ccs. distilled water throughout dry weather.

Soil "A."

Pot No.		12/3	20/3	26/3	2/4	15/4	18/4	20/4
1. Calapogonium Very good growth ...	pH percolate	6.0	5.2	5.0	6.8	6.0	6.4	6.8
	N as NO_3 p.p.m.	20	24	16	12	0.7	trace	trace
2. Bare ...	do.	6.2	6.2	7.0	6.8	6.4	6.0	6.4
		11	20	16	10	8	12	10
3. Calapogonium Very good growth ...	do.	6.4	6.1	3.7	7.0	6.8	6.8	7.2
		16	24	17	8	0	0	0
4. Bare ...	do.	6.0	lost	6.0	7.0	6.4	6.4	6.4
		trace		8	nil	0	0	2

"Soil A."—(Contd.)

5. Grass ...	do.	6.2 trace	6.4 trace	6.6 trace	6.8 0	7.4 0	6.8 trace	6.8 0
6. Calapogonium Very bad growth ...	do.	5.0 16	5.2 20	5.0 18	5.4 10	5.4 6	4.6 3	4.4 4
7. Calapogonium Bad growth ...	do.	6.1 9	6.0 12	6.2 2	5.4 12	6.0 4	6.2 2	6.4 2
8. Bare ...	do.	6.2 10	6.2 16	5.4 12	7.0 11	7.4 6	6.4 3	4.4 4
9. Bare ...	do.	6.2 12	5.3 28	4.6 17	5.2 24	5.6 12	5.2 8	4.6 8
10. Calapogonium Very bad growth ...	do.	5.7 12	6.4 2	6.0 10	6.4 3	7.0 0.4	7.4 trace	6.4 trace

TABLE III.

Soil "B."

Pot No.		12/3/29	20/3	26/3	2/4	15/4	18/4	23/4	26/4
1. Grass ...	pH percolate N as NO_3 p.p.m.	7.0 trace	6.8 0	6.0 0	6.0 trace	6.4 0	0.4 0	5.4 0	6.0 0
2. Calapogonium Very good growth ...	do	6.2 21	5.6 14	5.0 16	6.0 8	6.0 trace	6.2 0	5.0 0	6.0 0
3. Bare ..	do	6.3 24	5.6 40	5.7 26	5.6 26	6.2 11	5.6 16	5.0 11	5.6 11
4. Calapogonium Very good growth ...	do	5.2 20	5.2 18	5.2 20	5.2 12	5.2 10	6.0 1	6.0 trace	5.6 0

"*Soil B.*"—(*Contd.*)

5. Calapogonium Very bad growth ...	do	* 5.2 20	5.5 3	5.0 20	4.4 19	5.0 10	4.6 10	4.4 2	4.6 9
6. Calapogonium Satisfactory growth ...	do	5.4 24	5.4 24	5.2 20	5.0 14	5.4 9	6.0 8	5.6 2	6.0 1
7. Bare ...	do	5.4 14	5.0 17	4.6 20	4.4 18	5.2 10	5.2 12	5.6 10	4.4 11
8. Bare ...	do	6.5 18	5.4 16	4.8 20	5.4 12	6.0 10	5.2 11	4.4 16	4.6 12
9. Calapogonium Bad growth ...	do	6.4 24	5.4 24	4.8 32	5.0 28	5.0 11	4.6 18	4.4 12	lost
10. Bare ...	do	6.0 24	5.2 24	4.6 36	5.0 19	5.0 11	4.6 16	4.6 11	4.6 10

A Rapid Approximate Method of determining the Exchangeable Bases in Non-calcareous Soils

BY

W. N. C. Belgrave,

*Plant Physiologist.**

The majority of inland soils in Malaya are so poor in exchangeable bases that determinations of separate constituents becomes a matter of difficulty, especially in view of the relatively great amounts of aluminium set free by treatment with N/20 HCl or NNH_4Cl. In addition these methods like the 'total' methods of Kelley or Bobko-Askinasi are time consuming. and too laborious for routine work. where all that is required is a rough classification of soils into groups of say less than 1, 1—3, 3—6, etc. M.E. of bases per cent.

The electro-dialysis methods are better but scarcely suited to the semi-skilled Assistants of a tropical laboratory.

Recently Kappen** has proposed a rapid method for non-calcareous soils in which the soils are shaken with N/10 HCl, and the residual acid titrated back with alkali.

The writer has spent some time in the search for suitable methods, and three were studied in some detail.

(1) The soil was leached or shaken with ammonium acetate or acetic acid and the leachate or an aliquot of the filtrate, evaporated, ignited, the residue dissolved in an excess of acid and titrated back. Moderately good results were obtained in silver or platinum dishes, but not in those of glass, porcelain or silica. The method was therefore discarded in favour of one which did not involve the use of expensive apparatus.

* In charge Division of Soils and Plant Physiology.

** Fort der Landev III p. 1009 '28. Abstracted in Ann. Sc Agronomigue 46 p. 76 '29 (original not seen).

(2) The soil was treated according to the method of Kappen. Two sources of error were found.

(a) A certain amount of chloride ion was absorbed (or adsorbed) by the soil, and in the case of very poor soils—this may cause an appreciable error. The difficulty can be met by titrating for chlorine.

(b) Many coastal organic soils gave coloured filtrates containing considerable quantities of iron and organic matter which completely upset the titration, giving in many cases a high negative result, i.e. more acid than was added.

(3) The idea was conceived of using an acid aluminium salt to get over the difficulty of 2 (b). The soil was shaken with M/60 $AlCl_3$, filtered, and aliquot taken and titrated back using brom-thymol-blue or phenol red as indicator.

The aluminium chloride method was adopted, and on 81 soils has failed twice only to give perfectly clear filtrates.

It suffers from the same disadvantage as the Kappen method, viz. the absorption of chloride and whenever the soil is base-poor, the chloride must be titrated. The writer uses the aliquot already titrated with alkali, adds 1 drop of dilute acetic acid to discharge the colour of the indicator, 3 drops of potassium chromate and titrates in the usual way with silver nitrate.

A theoretical objection to the $AlCl_3$ method might be that $AlCl_3$ destroys the base complex without using up Al (or the equivalent H) vide the results of Magistrad* but the comparative figures shown for the $AlCl_3$ and Bobko-Askinasi methods do not support this, at any rate for the dilution used and for our soils, the results agreeing well within the limits of accuracy defined above.

The agreement found also answers the possible objection that the results of determinations on aliquots cannot be compared with those on leaching.

* Univ. of Arizona Tech. Bull. No. 18, 1928.

Method.

20, 10 or 5 grams of soil (depending on richness in bases) is warmed to 50°C with 100 ccs. of M/60 $AlCl_3$ shaken at intervals for half hour, filtered, and 50 ccs. titrated with N/10 soda using phenol red as indicator. If the base content is less than 3 M.E.% the chloride content of the aliquot is then titrated with N/10 $AgNO_3$ using potassium chromate as indicator and the absorption found deducted from the apparent base content.

Kappen has pointed. out that the 'total' methods of Kelley and Bobko-Askinasi give results seriously in error if the exchange hydrogen liberated is not taken into account. The annexed table confirms this.

Summary.

A rapid approximate method of determining total bases by the use of M/62 $AlCl_3$ is described.

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TABLE.

Soil	Bases by $AlCl_3$	Absorption of Cl from $AlCl_3$	Bases by HCl	Absorption of Cl from HCl	(a) Including exchange H	Bases by Bobko-Askinasi (b) Excluding exchange H.
			All figures	are M. E. %		
" Quartzite " Sandy ...	0.8	0.1	1.0	0.1	3.0	0.7
" clay 50% top ...	1.0	1.0	-	-	2.2	1.0
" " " sub ...	1.1	1.7	-	-	2.4	1.3
" Raub high level " ...	1.0	1.2	1.2	1.8	3.5	1.2
" Granite " ...	0.7	0.2			2.8	0.9
" 19 B Rich Coastal clay " ...	9.2	0.3	8.3	0.3	17.5	9.9
" 41 B Poor Coastal loam " ...	0.9	0-2	−10.1	0.2	7.6	1.2
".43 B Rich Coastal clay " ...	9.6	0.3	-	-	8.0	8.0

Studies on Tapioca.

V. R. Greenstreet,

Assistant Agricultural Chemist.

III. Further Notes on the Determination of Phosphoric Acid in Tapioca Material by the Coeruleo-Molybdate Method.

In connection with the investigation of the impoverishment of the soil by tapioca, further determinations[1] of phosphoric acid in various samples of tapioca material and fertilisers have been carried out by the coeruleo-molybdate colorimetric method and the results compared with the molybdate-magnesia gravimetric method.

All the solutions were prepared by thoroughly igniting the material at 700°C, taking up the ash with hydrochloric acid and eliminating silica by repeated evaporation to dryness and baking at 110°C.

Since it has been shown by various workers[2] that excessive amounts of ferric iron and acid interfered with colour development determinations of these two radicals were also carried out. The proportion of ferric iron was found to be in every case only of the same order or less than the proportion of phosphoric acid. Since the writer had already worked with solutions containing 15 times as much ferric iron as phosphoric acid without appreciably affecting the result it was decided that the iron content could be ignored. Acidity was determined by titrating with standard alkali before dilution. In the process of developing the tint about 1 per cent of sulphuric acid is added as Reagent A so that it seemed unnecessary to neutralize the hydrochloric acid which was present in relatively minute quantities.

Table I shows the amount of phosphoric acid in the various materials as determined by the colorimetric and gravimetric processes, the error calculated on the gravimetric

1. Greenstreet. M.A.J. XVI. 70, 1928.
2. Belgrave. Ibid. XVI. 361, 1928.

ERRATUM.

Vol. xvii No. 7 Page 211. Table 1. All the figures in the columns under "Phosphoric Acid" and "Error" should be raised one line, e.g. 0.094, 0.083, and -12, should refer to Stem C.S.S.

TABLE I.

Phosphoric Acid Content of various materials and acidity of the test solutions.

Substance.	Acidity Milligrams HCl in 100 c.c. of test solution.	Phosphoric acid P_2O_5		Error of colorimetric determination calculated on gravimetric determination
		Gravimetric determination	Colorimetric determination	
		per cent.	per cent.	per cent.
Stem C.S.S. -	1.5			
Tuber C.S.S. -	1.7	0.094	0.083	- 12
Tuber F2 -	2.5	0.11	0.12	< 10
Tuber E1 -	4.8	0.11	0.12	< 10
Tuber C.M.S. -	1.5	0.13	0.11	- 15
Stem F2 -	1.3	0.14	0.11	- 21
Tuber J2 -	1.7	D.0.140/0.147	0.15	< 10
Stem J2 -	1.5	0.14	0.13	< 10
Tuber L.K.J. -	...	0.14	0.14	Nil.
Stem E1 -	3.5	0.15	0.13	- 13
Tuber E2 -	2.0	0.15	0.16	< 10
Tuber F1 -	6.0	D.0.156/0.160	0.16	Nil.
Stem C.M.S. -	1.7	0.16	0.15	< 10
Stem L.K.J. -	...	0.17	0.14	- 18
Stem A1 -	0.8	0.17	0.15	- 12
Stem F1 -	0.7	D.0.203/0.250	0.20	Nil.
Tuber G2 -	0.3	0.20	0.19	< 10
Tuber H1 -	0.3	0.20	0.18	- 10
Stem E2 -	0.5	0.21	0.25	+ 19
Stem G2 -	0.7	D.0.240/0.260	0.25	Nil.
Leaf C.S.S. -	0.2	D.0.332/0.333	0.31	< 10
Leaf K2 -	0.3	0.38	0.36	< 10
Leaf E1 -	0.4	0.42	0.44	< 10
Leaf C.M.S. -	0.3	0.47	0.52	+ 10
Leaf L.K.J. -	...	0.48	0.48	Nil.
Leaf F1 -	0.4	0.48	0.48	Nil.
Leaf B1 -	0.6	0.49	0.49	Nil.
Leaf E2 -	0.5	D.0.523/0.528	0.46	- 13
Leaf J2 -	0.4	0.53	0.53	Nil.
Leaf G2 -	0.7	D.0.567/0.577	0.58	< 10
Cattle Manure -	...	0.62	0.69	+ 11
Superphosphate A	...	0.72	0.77	< 10
Superphosphate B	...	16.2	17.1	< 10
		16.4	17.2	< 10

D. Denotes duplicate determination.

result (when more than 10 per cent) and the amount of hydrochloric acid in the test solution. A proportion of phosphoric acid of about 1 part in 2½ million was found to be the best concentration for comparing the tints.

Results of analysis indicate there to be no relationship between the acidity of the solutions examined and the error in the determination of phosphoric acid. Out of 33 samples examined, in 13 instances the colorimetric result was lower than the gravimetric, in 12 instances the colorimetric result was higher than the gravimetric, while in 8 instances the results were identical: in only 8 cases did the discrepancy amount to more than 10 per cent. Since all the solutions were prepared similarly there is no evidence to attribute interference with colour development to either iron or acidity.

Comparison of these results with those described in the writer's previous paper shows a marked improvement on the accuracy previously attained. Since identical methods were employed it appears that the increased accuracy is attributable to an increase in skill of manipulating the colorimeter and matching the tints.

It is possible that the further work on the subject which the writer hopes to carry out in the near future may yield still more satisfactory results.

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THE

Malayan Agricultural Journal.

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Division of Agriculture.

Annual Report for 1928.

Staff.

Mr. B. Bunting, Agriculturist, was in charge of the Division throughout the year. Mr. J. Lambourne, Assistant Agriculturist, returned from leave and resumed duty at the Experimental Plantation, Kuala Lumpur, on the 8th March. Mr. J. N. Milsum, Assistant Agriculturist, proceeded on leave on the 6th April. Mr. J. L. Greig was appointed an Assistant Agriculturist and assumed duty at the Experimental Plantation, Serdang on the 15th November. Mr. F. S. Banfield, Horticultural Assistant, was transferred from the Experimental Plantation, Serdang to Maxwell's Hill Gardens, Taiping on the 27th December.

Expenditure and Revenue.

The total expenditure incurred on the Experimental Plantations during the year under review was $135,829.89, while the revenue from various sources over the same period amounted to $21,547.82.

Experimental Plantation, Serdang.

Staff.—Mr. J. N. Milsum, Senior Assistant Agriculturist, was in charge of the plantation until he proceeded on leave on the 6th April, when Mr. T. D. Marsh, Assistant Agriculturist (West Division) acted in this capacity during the remainder of the year. Mr. E. A. Curtler, Assistant Agriculturist (East Division), was stationed on the plantation throughout the year, while Mr. J. L. Greig, who was

appointed an Assistant Agriculturist, assumed duty at Serdang on the 15th November and was stationed on the plantation during the remainder of the year.

Mr. F. S. Banfield, Horticultural Assistant, was also stationed on the plantation until the 27th December, when he was transferred to Maxwell's Hill Gardens, Taiping.

Development.—The development work on the plantation during the period under review has been mainly connected with the construction of roads and culverts.

The area now opened is approximately 800 acres, which includes a reserve of about 25 acres for the proposed Agricultural School and about 30 acres of roads and building sites, the balance of 745 acres being planted with various economic crops.

Planting Operations.—The following is a list of the more important crops which have been planted during the year:—

Tapioca varieties 18 acres, *Hydnocarpus anthelmintica* 17 acres, Tuba root (Derris) 15 acres, Sisal Hemp 7½ acres, Fruits (various) 7 acres. Brazil nut 5 acres, Oil palm varieties 3½ acres, *Taraktogenos Kurzii* 3 acres, Sugar cane 2 acres, Lemon grass 1½ acres, Cinnamon 1 acre, Manila hemp 1 acre and Palmyra palm 1 acre.

Fruit Nursery.—Considerable attention has been given to the propagation of native fruits and the nursery is now well-stocked with plants of various types of fruits.

Distribution of Planting Material.—The demand for different forms of planting material has increased considerably during the past year and large quantities of seeds and cuttings of various economic plants were forwarded to headquarters for distribution throughout the Peninsula.

The planting material mostly in demand included seeds of oil palm, coffee and cover plants, cuttings of sweet potatoes, tapioca and guinea grass and seedlings of local fruits

Introduction of Planting Material.—The following is a list of various forms of planting material introduced at Serdang during the year:—

Bud-grafts of Kapok were received from the Economic Gardens, Buitenzorg, Java.

Seeds of *Dolichos falcatus* syn. *D. labialis* and *Grevillea robusta* were received from the Department of Agriculture, Ceylon, *Elaeis guineensis* Diwakawaka or Ayara Mbana from the Director, Algemeen Proefstation, A.V.R.O.S., *Annona aquamosa*, *Inocarpus edulis*, *Dillenia philippinensis*, *D. rieffenscheidia*, *Sandoricum koetjape* and *Terminalia edulis* from the Bureau of Agriculture, Manila, *Hydnocarpus Wightiana* from Ernakalam, Malabar, South India and Kanara coast Division, Bombay, Jugo bean from S. Rhodesia, *Azadirachta indica* from India, Dangri Tea from Dibrugarh. Assam and *Tephrosia toxicaria* from the Director of Agriculture, British Guiana, through the Economic Botanist, Kew.

Labour.—In compliance with instructions from Government the minimum wage for able-bodied labourers was raised to 50 cents per day for men and 40 cents per day for women as from the 1st. January. The working day was, however, extended by half an hour as from this date with satisfactory results.

A school was provided for the education of Tamil children resident on the plantation.

Health.—The general health of the labour force has been fairly good throughout the year, but the incidence of malaria was higher during the dry months.

A visiting Medical Officer attends the plantation fortnightly for a general inspection. A resident Dresser was stationed on the plantation as from the 19th October.

Buildings.—The following is a list of new buildings erected on the plantation during the year:—

Two Temporary Quarters for Subordinate Officers, 1 Dispensary, 1 School and Creche, 1 Creche, 3 Kitchens (5 rooms), 2 Latrines and 2 Incinerators.

Experimental Work.—The experiment started last year with the object of ascertaining the optimum period between harvesting the leaves of sisal hemp, which is being carried out in collaboration with the Agricultural Chemist, was continued.

A similar experiment with gambier, which is also being carried out in collaboration with the Agricultural Chemist, regarding the effect of harvesting the fresh leaves at intervals of 3, 4 and 6 months respectively, has also been continued.

An experiment was carried out during the year on an area of 4 acres to test the effect of harvesting "tuba puteh", a variety of *Derris elliptica*, at intervals of 21, 23, 25 and 27 months from date of planting on both the yield and toxicity of the sun-dried root. Representative samples of (a) fine roots and (b) thick roots from each plot were submitted to the Agricultural Chemist for analysis and determination of toxicity.

A further experiment of harvesting "tuba erect", a variety of *Derris malaccensis*, at different intervals on the same lines as that carried out with "tuba puteh" has been started, but in this case the root will be harvested at intervals of 19, 21, 23, 25 and 27 months respectively.

An experiment with oil palms has been laid down in Block 2 to ascertain the effect of cutting out all female inflorescences on palms up to four years old from planting in the field.

The observations will include (a) rate of growth and (b) whether the treatment has a stimulating effect by causing the production of an abnormal number of female inflorescences.

A further series of experiments was started on the oil palms in Block 21 in which the following investigations are being undertaken:—

(1) A block of 95 palms are being kept under close observation and individual yields recorded.

(2) A pollination experiment, of approximately four acres, has been started. One set of sixty three palms has six female inflorescences artificially pollinated per annum, another set of the same size twelve per palm, a third set has all female inflorescences artificially pollinated, while a fourth set is retained as a control, on which no artificial pollination is practised.

(3) A preliminary experiment, also about four acres in extent, has been started to compare the effect of "normal"

pruning with "minimum" pruning, alternate rows throughout the area receiving one of the methods. "Normal" pruning consists of cutting off all leaves up to but exclusive of those with fruit bunches in their axils, each leaf being cut off at the same time as the bunch in its axil is harvested, this is the usual estate practice in Malaya. "Minimum" pruning consists of removing only such leaves as have turned yellow, this is the method now considered to be the more desirable.

Experiments have also been started in connection with the breeding of improved strains of oil palms by bagging the female inflorescences of ten of the highest yielding palms recorded during the past four years.

Arrangements were made to commence taking preliminary records of the individual yields of 120 oil palms in Block 21 at the beginning of 1929 with a view to carrying out manurial experiments later.

The observations which are being made on oil palms in the main avenue on the plantation were continued. The results of these observations are published periodically in the Malayan Agricultural Journal.

An experiment was carried out in connection with the harvesting of vetiver grass plots, which are arranged to determine the yield of roots at different planting distances. These plots were harvested at fortnightly intervals for a period of 3 to 6 months and samples of the sun-dried roots were submitted to the Agricultural Chemist for analysis in order to test the variation in oil content of root harvested at different periods of growth.

Other experimental work carried out during the year included (a) the effect of the cultivation of tapioca with regard to soil exhaustion (b) variety trials with tapioca and coffee growing under various conditions and (c) the individual yields of *Hydnocarpus anthelmintica*, *H. Wightiana*, areca nuts and cloves.

Stock Farm.—The stock farm at Serdang was further augmented during the year by the introduction of 4 pure-bred Montgomery incalf cows and 1 pure bred Montgomery bull from the Imperial Department of Agriculture, Pusa. These dairy cattle were received from India at the end of

December and within a few days of arrival one of the cows gave birth to a pure-bred bull calf. The other three cows, having been covered with a pure-bred Ayrshire bull, will eventually produce Ayrshire-Montgomery calves and it will be interesting to note how these cross-bred calves will thrive under local climatic conditions.

The following is a complete list of dairy herd at Serdang at the end of the year:—

1 Montgomery bull (aged), 1 Montgomery bull (imported), 8 Montgomery cows, 1 heifer (3 years), 3 Montgomery bulls (2½ to 3 years), 3 Montgomery heifers (1½ years), 3 Montgomery bull calves, 2 Ayrshire heifers (1½ to 2 years) and 1 Jersey bull (2 years).

The conditions at Serdang apparently suit the Montgomery breed of cattle and both young and old stock appear to thrive well on the plains in this country.

The pure-bred Ayrshire and Jersey stock are not so well suited for the plains in Malaya, but crosses of these breeds with the Montgomery stock will probably prove more suited to such conditions.

An area of about 20 acres of land reserved for the cattle farm has been cleared of timber and planted up with various grasses for grazing purposes.

A further supply of pure-bred Large Black and pure-bred Middle White pigs has been ordered from the Hong Kong Dairy Farm for carrying out pig-breeding experiments at Serdang.

Meteorological Observations.—Rain fell on 146 days during the year, giving a total rainfall of 105.48 inches, which is an increase of 7.91 inches on the previous year. The driest month during the year was June with a precipitation of 2.06 inches and the wettest month was October with a precipitation of 22.21 inches.

The mean maximum temperature during the year was 91.3 F (highest maximum 94.0 F) and the mean minimum 70.8 F (lowest minimum 68.0 F).

Experimental Plantation, Cameron's Highlands.

Staff.—Mr. J. P. K. Wilkins, Superintendent, remained in charge throughout the year.

Situation.—This plantation is situated at Tanah Rata in the south-eastern corner of the Highlands and has a mean elevation of about 4,750 feet above sea-level.

Development.—The area of 76 acres previously felled and partially cleared of timber has been gradually developed and at the end of the year about 50 acres of this area had been stumped and terraced ready for planting.

Plant Introductions.—The following is a list of planting material introduced during the past year:—

Seed of Betjan, Dhonjan, Rajghur and Dangri tea from Dibrugarh, Assam, Mysore and Malabar varieties of Cardamoms, Kent's Arabica coffee from Mysore, Himalayan raspberry from the Royal Botanic Gardens, Kew.

In addition various hill food crops, fruits, green manures and ornamental plants were established.

Nurseries.—The nursery area has been extended during the year to a little over 2 acres. The beds are well-stocked with planting material of numerous economic plants for trial on the Highlands and include about 50,000 tea seedlings and 10,000 Coffee arabica seedlings now ready for planting out in the field.

Planting Operations.—The following planting operations were carried out during the year:—

An area of about 5½ acres on the banks of the Bertam River were planted with various fodder grasses during April. An acre of Carpet grass, *Axonopus compressus*, was also planted out in May for grazing purposes.

Half an acre of *Cinchona Ledgeriana* and *C. succirubra* was planted at a distance of 4 ft. × 4 ft. in the open in May. A further 2 acres of *C. Ledgeriana* were planted at a distance of about 6 ft. × 6 ft. apart under light jungle shade during August/September.

An area of 3½ acres was planted with Arabian coffee.

An area of about $5\frac{1}{2}$ acres was planted with Betjan (9,643 seedlings) and Dangri (4,532 seedlings), varieties of Assam tea.

Crops in the Field.—Of the major crops planted in the field a small plot of Assam tea, planted in January, 1926, continued to give satisfactory yields. The crop harvested from this plot between the 1st January and 31st December, 1928, amounted to 86 lbs. of dry tea. Since the area of this plot is only one-sixth of an acre this figure gives a calculated yield of approximately 516 lbs. of dry tea per acre per annum.

The Coffee arabica planted out in November, 1927, has shown excellent growth so far and appears to be particularly suited to the conditions on the Highlands.

Meteorological Observations.—Rain fell on 232 days during the year, giving a total rainfall of 83.39 inches as against 127.26 inches in 1927. The driest month during the year was January with a precipitation of 1.90 inches and the wettest month was December with a precipitation of 14.17 inches.

The mean maximum temperature during the year was 72.5 F. (highest maximum 79° F.) and the mean minimum 56.6° F. (lowest minimum 45° F.)

The total sunshine recorded was 1,637.85 hours for the year, which gives an average of 4.49 hours sunshine per diem, as against 4.0 hours during 1927.

Experimental Plantation, Kuala Lumpur.

Staff.—Mr. H. Ritchings, Horticultural Assistant, was in charge of this plantation until the 8th March, on which date Mr. J. Lambourne, Assistant Agriculturist, took over on return from leave and was in charge during the remainder of the year.

Maintenance.—The plantation was kept in good order throughout the year. Several sites on the plantation were handed over to the Public Works Department during the year for building purposes, which necessitated cutting out several mature areas of rubber.

Plant Introductions.—Seeds of *Tephrosia toxicaria* were received from the Director of Agriculture, British Guiana, through the Economic Botanist, Kew.

These seeds were planted at Kuala Lumpur at the end of July and the plants established have so far shown excellent growth. The roots of this plant contain a poisonous principle, somewhat similar to "tuba" root (*Derris*).

Experimental Work.—A number of nursery beds on the plantation were again allotted to the Economic Botanist for the purpose of carrying out selection work on several minor economic crops such as groundnuts, maize and soya beans.

The Mycologist was also given a small area for planting up plots of different varieties of bananas in connection with his investigations regarding Panama disease.

Small plots of various leguminous cover crops and green manures have been maintained in the nurseries for demonstration purposes.

Planting Material.—Attention was again given to the propagation of planting material for purposes of distribution.

General Agriculture.

A much greater interest has been taken throughout the year regarding the cultivation of crops other than rubber, which is undoubtedly due to the serious slump in the price of this important commodity. Judging by the large number of enquiries which have been received by the Division during the period under review in connection with the cultivation of such crops as oil palm, coffee, tea, pineapples, sisal and tuba root, far greater attention is being given to the possibility of establishing new agricultural industries in Malaya.

Coconuts.

The price of copra has again shown a slight reduction when compared with the previous year. The Singapore quotations show that the highest price for sun-dried copra was $12.00 per picul in January and the lowest $10.05 per picul in October, giving an average price of $10.92 per picul throughout the year, as against $11.17 per picul in 1927. The exports of copra from the Federated Malay States for

1928 amounted to 68,504 tons valued at $11,459,708/- as against 57,536 tons valued at $10,142,826/- in 1927.

Oil Palms.

Considerable activity has taken place during the past year in connection with the planting of oil palms and according to statistics collected departmentally it is estimated that the total area in Malaya planted with oil palms at the close of the year was approximately 24,730 acres, which shows an increase of about 5,000 acres over the area planted at the close of 1927.

The reserve land held by oil palm estates in British Malaya at the end of 1928 is estimated at about 27,000 acres, while an additional area of 25,000 acres represents alienations of land upon which planting operations have not yet commenced.

An experiment carried out at Serdang in collaboration with the Acting Agricultural Chemist to test the percentage of oil in oil palm fruits at varying stages of ripeness was completed. The results of these investigations show that there is a distinct loss of oil when unripe fruits are harvested and that only a fictitious increase of oil is obtained by storing the ripe fruits after harvesting owing to loss of moisture.

The price of oil palm products has remained very steady throughout the period under review and at the close of the year sales of palm oil were recorded at rates varying from £38 to £38-10 per ton, while the latest market reports indicate an advance in the price of this commodity during 1929. The price of palm kernels remains nominal at about £20 per ton, c.i.f. Liverpool.

The exports of palm oil products from the Federated Malay States during 1928 were 1,460 tons of palm oil, valued at $384,954/-, and 261 tons of palm kernels, valued at $43,475/-. The corresponding exports during 1927 were 852 tons of palm oil, valued at $269,966/-, and 178 tons of palm kernels, valued at $31,763/-.

Tapioca.

The experiments in the cultivation of tapioca, being carried out at Serdang in collaboration with the Agricultural Chemist, have been continued. A block of 10 acres reserved

for this purpose is sub-divided into 10 plots which receive different forms of treatment in order to ascertain the effect of continuous cropping on the yield of tapioca (a) without manuring, (b) with green manuring and (c) with artificial manuring.

The present prices of tapioca products are so low as to render the cultivation of this crop almost unremunerative.

Pineapples.

A number of introduced varieties of pineapples previously established at the Experimental Plantation, Serdang are now beginning to produce fruits so that it will soon be possible to make a general classification of the different types.

The export of canned pineapples from the Federated Malay States during the year was 3,688 tons, valued at \$663,555/-, as against 3,968 tons valued at \$822,719/- in 1927.

Coffee.

Considerably more attention is now being given to the cultivation of this crop and numerous enquiries have been received regarding the cultivation, on a small scale, of both the liberian and robusta varieties of coffee to meet the demands of the local markets.

Experiments with coffee planted on flat land, which are being carried out at Serdang, indicate that the coffee bushes thrive much better on clean weeded areas than when interplanted with some of the low-growing leguminous types of cover crops. Further, some form of light shade appears to be necessary in order to obtain the best results and for this purpose *Gliricidia maculata* is being given a trial.

At the present time there is very little raw coffee exported from this country and practically the whole of the produce is consumed locally. Generally speaking the liberian type is preferred to robusta on the local markets, consequently it usually commands a slightly higher price than robusta.

Tuba Root.

The investigations which are now being carried out at the Experimental Plantation, Serdang with several forms of tuba root (*Derris*) show that there are considerable variations

in the relative toxicity of the different varieties under cultivation, i.e.., the form known as "erect tuba", *Derris malaccensis*, has a much higher toxic content than that commonly known as "tuba puteh", *D. elliptica.* Further, the fine roots show a higher toxicity than the large roots in all cases.

The extended use of tuba root in the preparation of proprietary insecticides has been responsible for an increased demand of the raw product during the past year and ready sales of the air-dried root have been made locally at prices varying from 25 to 30 cents per lb., Straits currency

Sisal.

The results of experiments with sisal, carried out at Serdang, have shown that it is possible to produce a fibre of fair average quality.

The percentage of fibre extracted from the mature fresh leaves was 4.5 per cent., which may be considered very satisfactory.

Experiments in the harvesting of leaves at different intervals of growth are being continued, but so far the results do not show any great differences in either the quality or strength of the fibre whether the leaves are cut at intervals of 2, 4 or 6 months.

Areca Nuts.

A small experimental area at Serdang was planted with this crop in January, 1923 and commenced to fruit about the middle of 1926. Individual yields have been taken from about 1,500 palms comprising this area with a view to selecting a number of the highest yielders.

Observations have also been made on the proportion of dry split nuts to fresh fruit. The results from young palms show that the average proportion of split nuts to fruit was 25 per cent.

There has been a considerable decline in the exports of arecanuts during the past year as shown by the following figures:—

The export of arecanuts from the Federated Malay States during the year was 814 tons, valued at $120,383/-, as against 1,356 tons, valued at $219,110/- in 1927.

Chaulmoogra Oil.

A further experimental area was planted up at Serdang during the year with *Hydnocarpus anthelmintica* and *Taraktogenos Kurzii*. Additional supplies of *Hydnocarpus Wightiana* seed were received.

The results of an analysis made by the Chemical Division of the Department, of seeds of *Hydnocarpus anthelmintica* produced at Serdang showed that the proportion of kernel was approximately 30 per cent. The kernel contained roughly 52 per cent. of oil, which, calculated on the whole seed, is equivalent to 16.0 per cent.

A sample of *Hydnocarpus anthelmintica* nuts were submitted for trial at the Leper Asylum, Kuala Lumpur at the beginning of the year. As a result of these trials the Medical Officer in charge reported that no distinction could be drawn between them and the nuts which were obtained from Siam.

Further, he was of the opinion that the locally-grown nuts were of equal value to the Siamese ones and commented upon the good quality of the sample supplied by this Department.

Cover Crops.

Several new cover plants were introduced during the year, the most promising of which is *Tephrosia toxicaria*. This plant is very similar in habit to *T. candida* and its roots are stated to contain a toxic principle much the same as that found in certain species of *Derris* (tuba root).

A detailed report giving full information on the cultivation of some of the more important cover plants and green manures was published in the Malayan Agricultural Journal together with illustrations of the plants described.

Publications.

The following articles were published by members of the Staff of the Agricultural Division during the year 1928:—

"Observations on Oil Palms", by T. D. Marsh, Malayan Agricultural Journal, Vol. XVI, No. 1.

"An Ornamental Shade Tree"—*Muntingia Calabura*, by F. S. Banfield, Malayan Agricultural Journal. Vol. XVI, No. 1.

"Annual Report of the Agricultural Division", by B. Bunting, Malayan Agricultural Journal, Vol. XVI, No. 4.

"Preliminary Report on the Cultivation of Candle-Nut at Serdang", by T. D. Marsh, Malayan Agricultural Journal, Vol. XVI, No. 5.

"Notes on Dolichos Hosei, syn. Vigna Hosei", by B. Bunting, Malayan Agricultural, Journal, Vol. XVI, No. 5.

"Cover Crops and Green Manures", by B. Bunting and J. N. Milsum, Malayan Agricultural Journal, Vol. XVI, No. 7.

GENERAL.

Several papers were read by the Agriculturist at Planters' meetings during the year.

As usual the technical officers of the Agricultural Division made numerous visits to estates throughout the country with a view to giving advice on various agricultural problems requiring investigation.

B. BUNTING,

Agriculturist, S.S. & F.M.S.

Kuala Lumpur,

2nd April, 1929.

Division of Chemistry.

Annual Report for 1928.

Staff.

The staff of the Division on December 31st, 1928 consisted of the following officers:—

Agricultural Chemist:—B. J. Eaton, (Seconded for service with the Rubber Research Institute). C. D. V. Georgi (Acting.)

Assistant Agr. Chemists.—C. D. V. Georgi, V. R. Greenstreet.

Assistant Analyst.—Gunn Lay Teik.

Mr. R. O. Bishop, M.B.E. Acting Agricultural Chemist, proceeded on leave to Europe on May 4th previous to resigning from Government Service, the writer being appointed to fill the vacancy of the acting appointment.

The departure of Mr. Bishop in May has affected the work of the division considerably, since no officer has yet been appointed to fill the vacancy and there have been therefore only two European officers in the Division for seven months of the year. Certain investigations have had to be postponed until the appointment of a successor to Mr Bishop.

Coconuts.—The investigation regarding the alleged deterioration in value of Straits copra as compared with that from Ceylon and Malabar based on the oil content of the material, has been continued.

Several analyses of copra from different estates have been carried out, as a result of which it appears that the average oil content of estate copra, calculated on a moisture-free basis, varies from 64—67 per cent. The higher figure is less than that quoted for either the Ceylon or Malabar product, the oil content of which, calculated on a similar basis, varies from 68—72 per cent.

The statement that the oil content of Straits copra is less than the lower limit quoted above is probably accounted

for by the fact that a certain amount of estate copra is graded down to a selling standard with native copra, which is frequently prepared from immature nuts and therefore deficient in oil content.

The reason for the lower oil content of estate copra is at present uncertain, although it has been suggested that the deficiency may be due to the different climatic conditions prevailing in Malaya. In order however to ascertain definitely whether there is any seasonal variation in the oil content it is proposed to carry out systematic analyses of estate copra over a definite period.

The suggestion made in the last Annual Report regarding the valuation of copra on its oil content is not favoured by the European dealers, principally on account of the difficulty of securing representative samples.

A special feature of the work on coconuts has been the analysis of 290 samples of copra from special nuts supplied by the Economic Botanist in connection with selection experiments on this crop. The investigation is at present incomplete.

As a result of enquiries received from London regarding supplies of coconut charcoal a series of experiments has been carried out with the assistance of the Forest Chemist to determine the quantities of the various bye-products obtained by the dry distillation of coconut shell. The results have been summarised for publication in the Malayan Agricultural Journal.

Oil Palm.—The oil palm industry has developed considerably during the past year, 1460 tons of palm oil and 261 tons of kernels having been exported. These figures are greatly in excess of last year, when only 852 tons of oil and 178 tons of kernels were exported.

This comparatively rapid development has given rise to a number of problems connected with the factory process as regards increasing its efficiency and maintaining a high quality of product.

There is little doubt that as regards the treatment of the whole fruit the efficiency of the centrifugal process, that has been adopted in Malaya, compares favourably with that

of the press system, as employed in Sumatra. The centrifugal process results in the recovery of oil that contains only a relatively small amount of sludge and can therefore be purified with only a very small loss of oil. Experiments show that the loss of oil in the purification process should not exceed 0.1—0.2 per cent. of the oil recovered from the centrifugal extractor.

The question of the increase of acidity of palm oil on storage has been studied. It has been found that with oil of average quality the increase should not exceed 0.1 per cent. per month, the acidity being calculated as palmitic acid per cent.

In view of the probability of shipment of oil in tanks in the near future an investigation was carried out regarding the increase in the iron content of palm oil on storage in an iron drum. The results showed that there was no increase after three months.

The writer, who accompanied the agriculturist on a visit to Sumatra in connection with the Oil Palm Industry, wishes to record here his appreciation of the kindness shown to him during the visit, especially by members of the A.V.R.O.S.

A translation of the latest publication from Sumatra on oil palm, "The Manufacture of Palm Oil" by Ir. H. N. Blommendaal, was made for the Division by Mr. L. A. J. Rijk, Librarian and Translator. Copies of the translation were circulated to all oil palm estate managers and others interested in the crop, while a detailed abstract of the publication was also published in the Malayan Agricultural Journal.

Jelutong.—With the exception of Jelutong all investigations on forest products, hitherto undertaken in the Chemical Division, are now undertaken by the Forest Chemist (Dr. T. A. Buckley, M.Sc., A.I.C.). This officer works in the Chemical Laboratory, so that the Division is still in close touch with the chemical investigations of the Forest Department.

As regards jelutong particular attention has been paid to the question of development of brittleness in the material on storage, usually referred to as oxidation. Experiments have shown that traces of soluble iron added to the latex

before coagulation induce oxidation in the product, for example, the addition of soluble iron to the latex to the extent of 1 part of iron to 20,000 parts of latex will result in the crude coagulum becoming completely brittle after exposure to air for two months. The process of refining the material by boiling with water retards the development of oxidation to a certain extent.

Since iron can be introduced so easily into jelutong latex before coagulation, either owing to the use of a rusty tin for coagulation or as an impurity in the coagulant, the importance of ensuring cleanliness of coagulating vessels and the use of pure coagulants will be realised.

In view of the statement that jelutong from Kedah is particularly liable to oxidation two series of coagulation experiments have been carried out with latex from that source. The results shewed that there are no grounds for this statement, provided the coagulation conditions described above are observed. The experiments also shewed that the reason for Kedah jelutong having no marked tendency to develop mould on storage is due to the small proportion of serum solids present in the latex. These amount to only one-third of those present in local latex.

An investigation regarding the variations in the moisture contents of individual blocks of jelutong in consignments from various sources showed that the amount of variation between two blocks may be as high as 12 per cent. In view of this large variation and the fact that the material is sold on a standard moisture content of 45 per cent. the adoption of standard methods of sampling and determination of moisture was urged. These questions are now under consideration by the American dealers.

It is satisfactory to record a considerable increase in the local jelutong trade during the past year, 1002 tons being exported compared with 576 tons during 1927.

Tapioca.

The work on tapioca at the Government Experimental Plantation, Serdang has been continued. The second crop of tubers has been harvested and complete analyses made of representative plants from different plots.

As already outlined in the Annual Report for 1927 this work necessitated the consideration of problems connected with the sampling of a crop, also a method for a rapid and reliable estimation of small amounts of phosphate. The results of both these investigations have already been published in the Malayan Agricultural Journal.

Tapioca estates in Pahang, Johore and Kedah have been visited and analyses of various plant materials from those estates made in order to obtain comparative figures.

Experiments have also been carried out in factories both in Pahang and Johore as regards the determination of the efficiency of the method of manufacture at present in use.

The results of the various investigation are being summarised for publication in the Malayan Agricultural Journal.

A series of experiments has also been commenced at the Government Experimental Plantation, Serdang, to determine the change in the carbohydrate content of the tuber as it reaches maturity.

Alcohol.

The results of the investigation on the production of alcohol (Samsu) from rice were published in the Malayan Agricultural Journal, various suggestions being made as regards increasing the efficiency of the present process followed by the local Chinese producers.

Experiments with the residue from Pineapple canning factories have shewn that the production of potable alcoholic liquor from the liquid obtained by pressing this waste material is a simple process. Interest has been aroused and it is hoped that in the near future a process on these lines will be developed for the utilisation of the large amount of waste produce annually in these factories.

Piqui-a Fruit.

Further analyses of piqui-a fruits (*Caryocar villosum*) have been made. Piqui-a resembles oil palm in this respect that the fruit contains two oils, one present in the pericarp. the other in the kernel.

Experiments shewed that if good quality pericarp oil is to be recovered the material must be treated without delay on account of the development of acidity.

An interesting feature of the fruit is the relatively high tannin content of the rind.

Miscellaneous Crops from Government Experimental Plantation, Serdang.

The division has conducted chemical investigations during the past year on various crops being cultivated experimentally at the Government Experimental Plantation, Serdang. Among the investigations may be mentioned the following:—

(*a*) *Tuba.* Determinations of the ether extract of roots of *Derris elliptica* of various ages have shown that this variety of *Derris* should be harvested approximately 23 months after planting, the amount of ether extract reaching a maximum after this period. A similar investigation is being carried out with roots of *Derris malaccensis* (erect Sarawak).

(*b*) *Sisal.* The systematic investigation of the fibre content of sisal leaves from the experimental plots has been continued. The fibre content of the leaves now being harvested exceeds 5 per cent.

(*c*) *Gambier.* Periodical determinations of the gambier content of cuttings, based on the total quantity of matter soluble in hot water, have been made. The quantity of soluble matter amounts to approximately 8 per cent of the weight of the fresh cuttings. The investigation is nearing completion and the results are being summarised for publication in the Malayan Agricultural Journal.

(*d*) *Kapok.* The results of analysis of samples of kapok shew that the material compares favourably with the Java product.

(*e*) *Chinese Wood Oil.* An examination has been made of seeds of *Aleurites montana.* The physical and chemical characteristics of the oil have been determined and found to be in close agreement with the

accepted standards for Chinese Wood Oil. The latter oil is obtained from seeds of both *Aleurites Fordii* and *A. montana.*

(*f*) *Hydnocarpus.* An investigation is in progress regarding the oil content of the seeds of *Hydnocarpus anthelmintica.* The physical and chemical constants of the oil will also be determined.

INVESTIGATIONS FOR ECONOMIC BOTANIST.

The Division has also co-operated with the Economic Botanist in regard to routine analyses connected with the following special investigations:—

(*a*) *Rice.* Periodical determinations have been made of the moisture contents of rice stored under varying conditions. The results shew a definite increase in the moisture content of the material with the arrival of the wet season. The investigation is being continued.

(*b*) *Soya Beans.* Complete analyses of ten samples of soya beans have been made in connection with selection experiments on this crop. The oil contents of the beans varied from 17.5 to 20.4 per cent, calculated on a moisture-free basis.

MISCELLANEOUS ANALYSES AND REPORTS ON INVENTIONS.

The miscellaneous samples reported on during the year included 2 samples of copra, 8 samples of coconut cake, 9 samples of jelutong, 5 samples of concentrated rubber latex, 16 samples of fertilisers, 1 sample of lime and 1 sample of soda ash. 502 gallons of distilled water were supplied to the Posts and Telegraphs Department during the year.

Reports on 31 Patent Specifications were submitted to Government during the year.

EXHIBITIONS.

A comprehensive exhibit of oil palm products and canned pineapples, including a small model of an oil palm estate, was despatched to the Canadian National Exhibition held at Toronto during August-September 1928.

An exhibit of oil palm products and tapioca was forwarded to the Malay States Information Agency for exhibiting at the British Industries Fair being held in London during February-March, 1929.

The writer acted as one of the judges in the Oils and Fats Section at the Malayan Exhibition held at Ipoh from August 3rd to 6th 1928.

PUBLICATIONS.

The following articles were published by the staff of the Division in the Malayan Agricultural Journal during the year.

1. "Bye-products of the Pineapple Canning Industry"—V.R. Greenstreet and Gunn Lay Teik, Volume XVI, No. 1.
2. "Samsu from Rice"—R.O. Bishop and Gunn Lay Teik, Volume XVI, No. 1.
3. "Studies on Tapioca. The Coeruleo-Molybdate Method for Determination of Phosphates"—V. R. Greenstreet, Volume XVI, No. 3.
4. "Studies on Tapioca. Sampling a Standing Crop"—V.R. Greenstreet, Volume XVI, No. 3.
5. "Division of Chemistry. Annual Report for 1927"—R.O. Bishop, Volume XVI, No. 4.
6. "Jelutong"—C.D.V. Georgi, Volume XVI, No. 5.
7. "Artificial Farmyard Manure"—V.R. Greenstreet, Volume XVI, No. 5.
8. "The Valuation of Jelutong"—C.D.V. Georgi, Volume XVI, No. 6.
9. "The Manufacture of Palm Oil". Abstract of Publication of Ir. H.R. Blommendaal—C.D.V. Georgi, Volume XVI, No. 6.
10. "Oil from Aleurites Montana"—C.D.V. Georgi and Gunn Lay Teik, Volume XVI, No. 8.

The Acting Agricultural Chemist collaborated with the Forest Economist (Mr. J. G. Watson) in the preparation of a short pamphlet entitled "Jelutong, its Tapping, Coagula-

tion and Refining". The pamphlet was translated into Chinese and published in "Ma Zoy Chow Nung Nyip Tsung Poh"—the Chinese Agricultural Journal.

Sd. C. D. V. GEORGI,
Ag. Agricultural Chemist, F.M.S. & S.S.

5th January, 1929.

Division of Economics.

ANNUAL REPORT FOR 1928.

Staff.—The Chinese Translator proceeded on leave in October, and was replaced by a Translator, lent by the Secretary for Chinese Affairs, for two days a week.

MAJOR CROPS.

Coconuts.—The Singapore market price for copra, which at the end of 1927 was $11.50 per picul (133⅓ lbs.), opened in January, 1928, at $11.90, around which price it stood until the end of the month. Thereafter, the price was maintained at between $11.35 and $11.50 until the end of May. The price subsequently shewed a downward tendency until the close of the year, when it was quoted at $10.05. The average price throughout the year was $10.92 as compared with $11.17, $11.80, $11.95, $12.12 in the respective years 1927, 1926, 1925 and 1924.

The satisfactory price of copra has enabled many estates to carry into effect drainage and other cultural operations during the last few years, the good effects of which are reflected in increased production. In view of the fact that about 80% of the coconut areas are held by small holders, the majority of whom have done little or nothing to improve their holdings, the increased production of the larger estates makes but little annual increase in the total copra production of the country.

Whereas the crops in 1927 were below average, those for 1928 were satisfactory in most districts.

The Economic Division commenced an investigation of costings in connection with coconut planting and cultivation, and the preparation of copra.

Arrangements were considered for the organisation of a Coconut Census in 1930.

TABLE Ia.

EXPORT OF COPRA FROM THE FEDERATED MALAY STATES.

(Part of which was exported direct to foreign ports, and part to the Straits Settlements).

Year.	STATE.									
	PERAK.		SELANGOR.		NEGRI SEMBILAN.		PAHANG.		TOTAL F.M.S.	
	Quantity Tons.	Value $	Quantity Tons.	Value $	Quantity Tons.	Value $	Quantity Tons.	Value $	Quantity Tons.	Value $
1924 -	38,554	6,914,055	12,903	2,427,188	1,179	203,930	561	95,839	53,197	9,641,012
1925 -	40,017	7,830,274	15,430	2,909,119	2,236	463,494	314	57,412	57,997	11,260,299
1926 -	44,542	8,905,033	16,963	3,212,553	3,417	575,451	907	158,733	65,829	12,851,770
1927 -	39,499	6,862,402	14,120	2,615,641	3,302	562,528	615	102,255	57,536	10,142,826
1928 -	45,451	7,535,319	20,148	3,435,968	2,251	381,675	654	106,746	68,504	11,459,708

TABLE Ib.

EXPORT OF COPRA FROM THE F.M.S. DURING 1928.

State	Exported to Straits Settlements.		Foreign Exports.	
	Quantity Tons	Value $	Quantity Tons	Value $
Perak -	34,474.67	5,720,130	10,976.34	1,815,189
Selangor -	10,665.06	1,775,325	9,482.52	1,660,643
Negri Sembilan -	2,244.57	380,660	7.04	1,015
Pahang -	633.40	103,360	20.50	3,386
Total -	48,017.70	7,979,475	20,486.40	3,480,233

TABLE II.

NET EXPORT OF COPRA FROM BRITISH MALAYA.

Year	Quantity (tons)	Value $.
1925	96,554	19,093,938
1926	104,653	21,852,330
1927	86,649	16,562,493
1928	95,091	18,747,129

Rice.—Statistics in connection with this crop will be found in the Annual Report of the Division of Economic Botany.

Miscellaneous Crops.—Apart from rubber, coconuts and padi, there are no crops grown in Malaya of any great importance, although four crops, viz:—pineapples, oil palms, coffee and tapioca, are of sufficient importance to be classified as "secondary."

The area under nipah, stated in table III, represents both plantation, for the production of power alcohol, and such areas of natural growth as are used for the making of roofing material.

Table III was compiled with the assistance of the Field Officers of this Department, the Land Officers and Managers of estates.

TABLE III.

Acreage of Miscellaneous Crops in Malaya, 1928.

State	Secondary Crops													
	Pineapples	Oil Palm	Tapioca	Coffee	Nipah	Areca nuts	Gambier	Bananas	Derris	Sago	Kapok	Tea	Spices
Selangor -	2,737	11,941	1,705	5,705	6,687	...	...	768	10	...	17	20	...
Perak -	457	5,240	512	404	4,290	374	...	1,157	387	...	76	...	..
Negri Sembilan -	105	600	836	585	445	7	329	2,316	269	...	...	8	1
Pahang -	3	482	616	718	...	100	1,856	...	...	...	308	25	...
Total F.M.S. -	3,302	18,263	3,669	7,412	11,422	481	2,185	4,241	666	...	401	53	1
Penang & Province Wellesley -	651	...	345	210	656	480	...	766	...	...	...	...	497
Malacca -	212	...	230	293	604	...	...	...	...	...	...	...	...
Singapore -	1,000	...	..	...	...	...	...	...	...	...	...	...	..
Total S.S. -	1,863	...	575	503	1,260	480	...	766	...	...	...	...	497
Johore -	35,000	6,477	14,000	2,500	...	8,500	1,600	...	2,000	600	...	...	...
Kedah -	...	...	5,000	500	...	...	...	1,000	...	...	...	500	...
Total U.M.S. -	35,000	6,477	19,000	3,000	...	8,500	1,600	1,000	2,000	600	...	500	...
Total Malaya -	40,165	24,740	28,244	10,915	12,682	9,461	3,785	6,007	2,666	600	401	558	498

Oil Palms.—Statistics relating to the present position of this industry will be found in Tables IV, V & VI. They shew that 4,985 acres were planted during the year 1928, making the total area under this crop in Malaya 24,740 acres. The planted area of the twenty-five estates with areas of land planted with oil palm is as follows:—over 2000 acres, six estates; between 1000-2000 acres, one estate; between 500-1000 acres nine estates; between 100-500 acres nine estates. It is estimated that the area to be planted in 1929 will amount to between 7,000 and 8,000 acres. Estates at present in existence with a portion of their land planted, have reserve land exceeding 25,000 acres representing alienations for the cultivation of this crop, but upon which planting has not yet commenced. It is estimated that the Government has earmarked a further 100,000 acres for alienation for this form of cultivation, but this figure must be accepted with caution, as in most cases it is not known what proportion of this area is suitable for oil palms, and certain areas are at present the subject of reconsideration in this respect. Six estates were producing oil during the year. The crops generally exceeded expectations; 1,460 tons of palm oil valued at $384,954, and 261 tons of kernels, valued at $43,475 were exported, representing an increase in weight of exports over 1927 of approximately 74% and 46% respectively.

A forecast of 1929 crops places production at 2,100 tons of oil and 430 tons of kernel.

Market prices for palm products have remained satisfactory throughout the year. The Malayan oil, on account of its purity, has commanded a premium over market quotations, and has mostly been put to specialised uses.

Palm kernels have obtained London market prices, which have varied from £20.15.0 to £20.3.0 per ton.

From the above figures it will be realised that the plantation palm oil industry in Malaya is gradually assuming a position of some importance.

Table IV.

Annual Exports of Palm Products from Malaya.

Year.	Palm Oil. Tons.	Palm Oil. Value. $	Palm Kernels. Tons.	Palm Kernels. Value. $
1926	726	254,165	180	36,708
1927	852	269,966	178	31,763
1928	1,160	384,954	261	43,475

Prior to 1926, the export of palm products were not shewn separately in the returns published by the Registrar of Imports and Exports, who supplied the above figures. Estate production was, however, collected and is shewn under.

Table V.

Yield in tons of palm oil and kernel in Malaya.

Description of Product.	Year. 1923	1924	1925	1926
Palm Oil	195	286	536	751
Kernels	50	81	110	168

TABLE VI.

Annual Planting (in acres) of Oil Palms in Malaya.

State.	Year.														Total.
	1913	1914	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	
Selangor -	12	2	100	253	270	470	821	394	1,876	1,845	1,412	1,994	2,030	462	11,941
Perak -	...	...	...	...	...	...	...	...	...	220	...	478	1,818	2,724	5,240
Negri Sembilan	...	...	...	...	...	...	...	...	...	...	...	100	500	...	600
Pahang -	...	...	...	...	...	...	...	...	...	...	...	...	...	482	482
Johore -	...	...	...	...	...	...	...	...	30	10	962	1,289	2,869	1,317	6,477
Total Planted Annually -	12	2	100	253	270	470	821	394	1,906	2,075	2,374	3,861	7,217	4,985	24,740
Total Planted to Date.	12	14	114	367	637	1,107	1,928	2,322	4,228	6,303	8,677	12,538	19,755	24,740	

Pineapples.—The area under this crop and the export of canned pineapples have been well maintained during the year, while the prospect of future supplies appears favourable.

Complaints are received by the Department from time to time regarding the packing and quality of canned pineapples from this country. Until the exports conform more strictly to the demand in this respect, it cannot be maintained that the industry is in a satisfactory condition, or that the maximum advantage is taken of the position held by Malaya's trade over that of its competitors.

Advantage was taken to discuss the subject with packers and exporters in Singapore during the visit to Malaya in May of Mr. E. M. H. Lloyd of the Empire Marketing Board. Agreement of the parties interested was reached on one point, that of embossing each tin with the quality of contents; but it is doubtful whether, if accepted by the Home trade, this will go very far towards improving the quality and grading, although it will safeguard the product from unscrupulous retailers.

The market has been somewhat erratic during the past two years owing to lack of co-operation amongst packers and exporters. The combine of packers, established in 1926, appears to have been unable to stabilise quality or prices. The Economic Division is investigating these problems and comparing the situation with that obtaining in other countries, with the object of consolidating the position which the canned pineapples of this country hold on the United King. dom market. In these efforts, the division has been in close touch with the Empire Marketing Board, and has also received willing assistance from the trade in Singapore.

Table VII.

Exports of Canned Pineapples from British Malaya.

Year.	Quantity.	Value (Straits $)
1919	255,973 cases.	3,286,001
1920	446,893 ,,	7,178,016
1921	662,630 ,,	6,210,383
1922	710,671 ,,	6,694,098
1923	889,941 ,,	5,874,858
1924	39,204 tons	8,873,977
1925	43,207 ,,	8,236,824
1926	40,634 ,,	7,669,784
1927	40,134 ,,	8,296,656
1928	46,400 ,,	8,421,230

Tapioca.—The cultivation of tapioca shews little advance; other crops, especially pineapples and coffee, receive more attention than tapioca as catch crops with rubber on newly opened land. The average price of "pearl" tapioca during the year was about $8.80 per picul, and of "flake" $8.50 per picul. The price for both grades shewed some decline during the year.

Table VIII.

The Tapioca Trade of Malaya.*

Year,	Imports.		Exports.	
	Tons.	Value. $	Tons.	Value. $
1925	6,010	762,582	37,000	4,818,528
1926	7,445	871,884	36,706	4,375,743
1927	8,085	905,672	25,189	4,243,992
1928	7,285	795,986	28,223	3,884,893

* Excluding the small trade in tapioca refuse.

Coffee.—An increased interest in coffee cultivation has been noticed during the past two years.. Many enquiries regarding this crop have been received from planters and owners of small holdings. There is still scope for further planting for the local market, in addition to which the produce should find a ready market abroad.

TABLE IX.

Malayan Imports and Exports of Raw Coffee.

Y ar.	Imports.		Exports.	
	Quantity lbs.	Value. $	Quantity lbs.	Value. $
1925	18,878,848	6,469,775	11,788,036	4,113,318
1926	18,515,244	6,084,110	9,931,876	3,319,597
1927	18,612,643	5,144,631	10,074,931	2,771,496
1928	14,073,996	4,136,554	6,781,929	2,029,425

Areca nuts.—Care in curing materially affects prices, and the local industry continues to suffer by reason of insufficient grading and carelessness in curing. Good sundried nuts always command a satisfactory price, though other grades also find their specialised market if of sufficiently high standard to compete with the products of other countries.

Production has been maintained, although the Johore main crop was reported to have fallen off.

Prices shew a decline over those of the previous year The average declared trade value per ton, of Exports in 1927 was approximately $206 per ton, while in 1928 it fell to $178 per ton. The average Singapore prices per picul of the various grades of areca nuts were as follows :—

Split $9.50; Kelantan Split, $8.30; Whole, $5.00; Palembang, $7.52; Red Smoked, $11.38; Sliced $16.15.

TABLE X.

Malayan Imports and Exports of Areca Nuts

Year.	Imports.		Exports.	
	Quantity Tons.	Value $	Quantity Tons.	Value $
1925	39,952	10,007,864	58,902	18,293,061
1926	40,497	9,396,674	63,012	17,286,800
1927	32,110	5,876,087	49,873	10,298,771
1928	45,185	6,980,937	69,303	12,196,258

Derris (Tuba root).—The area under this crop is very small, owing to the difficulty in establishing a satisfactory market. The use of this root as an insecticide is being investigated in several countries, for which purpose the Division has forwarded bulk samples.

Kapok.—No further advance has been made in the cultivation of kapok, the industry still being confined to scattered areas in native holdings.

An attempt has been made to arrange for the marketing of kapok seed from holdings along the Perak river. The amount of such seed is inconsiderable, and is at present discarded. Its sale, however, might prove an incentive to planting, and would be a welcome addition to the income of the Malays in the district. An exporting firm was placed in touch with this source of seed, and the organisation of collecting seed and forwarding to Teluk Anson is now available.

Rubber Seed.—The import of rubber seed into Malaya during 1928 amounted to 5 tons, valued at $28,590 The value per ton, viz $5,719, indicates that this seed was all destined for planting purposes. The export of rubber seed over the period was 7,905 tons, valued at $246,940, i.e. $31 per ton, practically all of which was intended for the extraction of oil. The establishment of a market for this bye-product of the rubber industry is due to an American Company which has organised the purchase of seed from estates.

The Division instituted an investigation of the marketing of rubber seed. It was estimated that the total seed crop of Malaya probably amounts to 200,000 tons, half of which might be economically marketed. The 1928 season was not considered one of abundant rubber seed yield. The collection was treated as a spare time occupation, and, especially on estates with Indian labour, one of considerable value to the labour force. The average cost of collection and packing amounted to $11.00 per ton. The purchasers offered $22/- per ton on rail, so that, provided the estate was not too distant from rail, or port, a profit of from 50 per cent. was obtained.

Supervision in collecting and packing the seed was in some cases insufficient, resulting in an accumulation at Malayan ports of stock which was unable to obtain a certificate of freedom from pests and diseases, which is required before entry into the importing country. Planters have gained valuable experience during the past season in the marketing of rubber seed, and it is anticipated that improved returns will result from a closer supervision of the collections.

Live Stock.

The Governments of the Federated Malay States have rendered annual returns of live stock for 1928 (see table XI) The stock in Negri Sembilan, and of cattle in Selangor, has been well maintained, but the number of cattle in Perak, and of all live stock in Pahang, shew a further serious decline of approximately 25% over the previous year. The effect of this diminution of stock in Pahang, caused chiefly by disease, floods, and unsuitable feeding, has proceeded unchecked since 1923, and is reflected in the reduced padi production returns of the State.

The Division placed these figures before the Agricultural Advisory Committee, whose suggestions have been referred to the States concerned.

It is understood that the Pahang Government has imported stock to replace, in part, that lost in the 1926 flood, and is fully alive to the seriousness of the present position. In view of the desirability of increasing food production, and of the relationship of live stock to the amount of food crops produced, an increase in stock, especially buffaloes for working the padi lands, must be considered of great importance

Table XI.

Live Stock in the Federated Malay States. 1928.

State	Bullocks			Buffaloes.			Goats and Sheep		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Perak -	5,713	7,349	13,062	6,309	8,913	15,222	7.759	17,622	25,381
Selangor -	-	-	9,024	-	-	1,617	No	returns.	
Negri Sembilan -	3,403	4,054	7,457	2,937	6,198	9,135	6,027	13,038	19,065
Pahang -	-	-	2,993	-	-	10,098	-	-	4,372
		Total	32,536		Total	36,072		Total	48,818

The census of poultry in Malaya has never been attempted, but the import of poultry and eggs points to the fact that there is room for an extension of poultry keeping in Malaya. A disease of poultry, the symtoms of which closely resemble Roup, has been reported to the Division from several districts. in particular from the Coast districts of Selangor, Negri Sembilan and Malacca. With the advice of a poultry expert, a special leaflet on Roup was published in the Malay language. It is to be feared, however, that the recognised remedies for this disease have not been particularly effective in the present case, and the loss of poultry has been considerable.

Publications.

Two illustrated booklets, viz: "The Oil Palm in Malaya", and "Malayan Pineapples", were prepared for the National Exhibition at Toronto, and were also later distributed at certain exhibitions in England.

"Malaya: Agriculture", an illustrated booklet, was compiled at the request of the Malay States Information Agency, and forwarded to London for publication.

"Annual Report of Division of Economics. 1927," Malayan Agricultural Journal, Vol. XVI, No. 4.

"The Agricultural Trade of Malaya for the first half year 1928", and "Copra and Coconuts" (a book review), Malayan Agricultural Journal Vol. XVI, No. 8

"London Market Price List 1928", Malayan Agricultural Journal, Vol. XV, No. 12.

"Notes on Oil Palm and Miscellaneous Crops", for the Planters Association of Malaya, Year Book 1927—1928.

Vernacular Publications.

Warta Perusaha-an Tanah, the Malay Journal of the Department. Volume VI, was published in four quarterly parts with thirteen illustrations. Owing to the demand, the distribution increased from 3,500 copies per issue at the end of 1927, to 5,000 copies during the second half of 1928 In all, 17,000 copies were distributed, against 12,000 for the previous year.

Special Malay Leaflet No. 6: "Roup—a disease of Poultry": 5,000 copies were printed for free distribution.

Chinese Agricultural Journal, Volume II, was published in four quarterly parts of 5,000 copies each, with a total of twenty-one illustrations.

The Co-operative Societies Department and the Rubber Research Institute of Malaya have co-operated in the use of the vernacular publications of this Department for their propaganda work amongst Asiatics.

The Sarawak Government has placed an order for 500 copies of all future issues of both the Malay and Chinese publications.

Vernacular publications are distributed free in the Federated Malay States and Straits Settlements. Expenditure for the year decreased by $1,720 to $4,023, while revenue from sales and advertisements increased by $795 to $2,363.

The printing of the Malay Journal was undertaken by the Government Printing Department, Singapore, from the beginning of the year. This resulted in an improvement in production and distribution.

Acknowledgments are again due to numerous contributors to both journals, as well as the writers and publishers of many articles which have been altered and adapted for presentation to Asiatic small holders.

The steadily increasing amount of correspondence from Asiatic readers of these journals is evidence of the utility of these publications.

Agricultural Exhibitions & Shows.

The following Exhibitions and Shows have been held during the year :—

Malacca,	July 21, 22.
Sixth Malayan Exhibition, Ipoh,	August 3—6.
Perak North, Taiping,	August 19, 20.
Lower Perak, Teluk Anson,	September 9.

All the above shows were held under the auspices of the Malayan Agri-Horticultural Association, of which the writer is Joint Hon: Organising Secretary. The Agricultural Economist officiated as a judge at two of the above district shows.

The Malayan Agri-Horticultural Association continued the publication of a quarterly magazine. Work has progressed in the laying out of a permanent site in Kuala Lumpur for the Annual Exhibition of the Association.

General.

The Agricultural Economist acted as Asst: to the Secretary for Agriculture in addition to the duties of his substantive appointment. He also served on the Advisory Committee for the School of Agriculture, Malaya; as Secretary of the Agricultural Advisory Committee, and (from June) as a member of the Co-operative Board.

D. H. Grist,

Agricultural Economist, F.M.S. & S.S.

7th March, 1929.

Tables Ia, Ib, II, V, VII, VIII, IX, X, are abstracted or compiled from official returns of the Customs Department.

Division of Economic Botany.

ANNUAL REPORT FOR 1928.

STAFF.

The writer was in charge throughout the year and the Staff of the Division was as follows:—

Dr. H. W. Jack, Economic Botanist (in charge).

Mr. W. N. Sands, F.L.S. Assistant Economic Botanist at Kuala Lumpur.

Mr. R. B. Jagoe, B.Sc. Assistant Economic Botanist at Kuala Lumpur.

Inche Mohamed Noor, Senior Agricultural Assistant at Parit Buntar.

Inche Tajudin, Junior Agricultural Assistant at Kuala Lumpur.

Inche Abdul Rauf, Field Assistant at Parit Buntar.

Inche Abdul Rahman, Field Assistant at Klang.

Mat bin Mat Saman, Mandor at Titi Serong.

Inche Abdul Jabbar, Clerk at Kuala Lumpur.

I have to thank all the above for loyal co-operation and for their good work throughout the year.

Mr. W. N. Sands was away in Europe on furlough for 7½ months during the year, and Mr. Jagoe was away on military duty in Hongkong for 3 weeks.

COCONUTS.

Individual yield records from 530 palms, growing under average estate conditions, have been maintained for eight years in succession, and the data thus collected have afforded instructive information concerning the variation in yield of individual palms in commercial plantations.

The data show that (1) over a period of eight years the coefficient of variability of an average population is as much

as 34% of the mean production per palm; (2) that variability in cropping per palm per annum ranges from 5 to 115 nuts on the block from which the data were collected; (3) that 19% of the palms of an average plantation are not profitable under normal treatment; (4) that 15% of the palms produces 24% of the total crop, and (5) that poor yielders remain poor yielders while good yielders are constant to that character.

In view of these results, the desirability of selecting seed nuts from known high producing palms is very evident.

Moreover, data have been compiled which show that the copra content of nuts from different palms (of the same variety) varies from 79% to 131% of the mean copra production per nut. Further data regarding variation in oil content of copra from different palms, and seasonal variation in oil content of copra from the same palms, are in process of compilation.

The coconut selection experimental area at Klang has been maintained in good condition and the general growth of the palms is satisfactory.

Beetle attacks are a constant source of trouble, an average of one beetle to every 18 palms being found each month throughout the year.

The area was visited by the Mycologist and Entomologist in connection with disease and pests and three palms have been cut out suffering from "bud-rot" while "kerengas" and scale insects have been a nuisance on several palms.

The manurial, cultivation, and catch crop experiments are also being maintained on this area. "Trenching" and row-mounding already appear to be effective methods of cultivation with heavy soils, for their effects on the young palms are very marked in greener foliage, more leaves and leaflets, and thicker crowns compared with adjacent "uncultivated" palms of the same age.

Manurial experiments on mature coconuts have been put into operation on Carey Island, on a block of 18 year old palms of which the yields of each palm are known for the last eight years. This block should afford much useful in-

formation, regarding efficient manuring for coconuts, in the next two years or so.

Data have been compiled from 30 representative estates in Malaya which show that there is a seasonal variation in output of copra per acre of 15% of the average crop. These data also show that the average production of copra per acre per annum, from European managed estates, is 8.734 pikuls (1,162 lbs.), and that 251 nuts are required to produce 1 pikul (133 lbs.) of copra. They also afford interesting figures of the average costs of various operations on coconut estates (See Malayan Agricultural Journal, Vol. 16, Nos. 8 & 11, 1928).

Records of the flowering and fruiting characters of races of dwarf palms, growing in the Parit Buntar office compound, were maintained for the 4th year in succession, and results will be published at an early date.

There has been little extension in the area planted with coconuts during the year though a slight increase (perhaps 3%) on the 1924 figures is probable.

An exhibit was staged at the Ipoh and Taiping Agricultural Shows, to show the variation in yield of nuts and copra per palm on average plantations.

Oil Palms.

Variation studies of individual palm fruits were maintained and preliminary arrangements have been made for compiling a palm crop register on a population of palms growing under good average estate conditions.

Arecanuts.

Excellent growth has been shown by the twenty varieties of arecanut palms growing at Klang though fire damaged one variety somewhat.

Soya Bean.

Selection experiments with this useful bean continue and promise interesting results. The number of selections was reduced during the year from 31 to 19 strains. The best

strains are those of the varieties Nos. 3 and 4, the former being a selection from a variety originally obtained from Siam, and the latter a selection from a local variety originally imported by Chinese agriculturists and grown for some years in Pahang (Manchis). Several strains of each of these varieties are promising and are being multiplied at the Serdang Experimental Plantation.

COTTON.

A collection of fifteen selections from Sea Island, Egyptian and Upland varieties were grown in small plots and, as usual, a fair crop was obtained. The cottons have been maintained in pure lines for the past seven seasons without any apparent deterioration in yield or quality of the lint.

The original selections have now been reduced to six, namely 2 Sea Island, 3 Egyptian and 1 Upland.

Lint valuations received from Shanghai mills (which favour Nos. 1, 2, 16 and 24) gave the following prices in August last:

E.B.	No.	1.	Egyptian	...	10	pence	per lb.
,,	,,	2.	,,	...	15	,,	,,
,,	,,	16.	,,	...	$14\frac{3}{4}$	,,	,,
,,	,,	6.	Sea Island	...	$18\frac{1}{2}$	,,	,,
,,	,,	5.	,,	...	$17\frac{1}{4}$	,,	,,
,,	,,	24.	Upland	...	10	,,	,,

It may be mentioned that No. 6 is the most prolific producer under local conditions.

Whilst it is unlikely that cotton will prove a remunerative crop along the West Coast of the Peninsula, yet it should be possible to grow selected varieties successfully in Kedah, Perlis, Kelantan and Trengganu, if expert advice and assistance concerning planting, cultivation, ginning, baling and control of pests and diseases was available to growers.

MAIZE.

As anticipated, considerable difficulty was experienced in maintaining the selected strains of local yellow flint maize

which had been inbred for five generations. Numerous crosses were made between them during the year, and further crosses will be made with the object of obtaining strong growing and heavy yielding types of the local varieties.

PADI.

The padi crops in the F.M.S. were slightly under the average of the past 14 years, partly because of late planting so that the standing crops were badly damaged by the March—April rains, but partly because of a drought, early in the growing season, followed by deep water at planting time. In the Straits Settlements the crops were good being well above the average.

In the Unfederated States an early drought affected the padi adversely so that the crop harvested were somewhat below the average over the last decade.

The summary of padi returns is shown as Appendix I.

Pure line selection work was maintained at Titi Serong along the lines already laid down and though good crops were grown, the lateness of the season resulted in much damage, and loss of grain during harvest, by continuous rains, so that the Krian crop was some 14% below average. Rat damage in Krian was distinctly less than usual during the past year—thanks to the energetic destrucion campaign carried on by the Field Division. Titi Serong pure lines continued to give satisfactory results throughout Perak North.

The Agricultural Field Officer, Perak North, reported increased yields in the Kuala Kangsar District varying from 21% to 72%, and in Larut District the increases range from 9% to 35%. In Pahang very heavy crops from selected seed were grown at Pekan on the flood silt of the previous year, yields up to 800 gantangs per acre having been recorded by the Agricultural Field Officer.

In Perlis the Adviser reported increases in yield from the pure lines Radin Nos. 2 and 13 of up to 50%, and stated that these strains were popular because of the ease of threshing them and their flavour.

In the Pasir Puteh District of Kelantan, the District Officer reported that Krian selected seed produced crops vary-

ing from 25% to 33% better than crops grown from local seed, and that "the rayats were most enthusiastic" to get further supplies of seed which have been sent. Seed has also been sent to Trengganu for trial and results should soon become available. Promising results are reported from Kedah and good results were also obtained in other areas. A particularly successful demonstration plot was planned and supervised by the District Officer, Jelebu, and yields of between 500 and 600 gantangs were obtained from selected seed as against local crops of around 400 gantangs,—more of these demonstrations are very desirable. The gradual increase in the number of padi inspectors should help towards gaining reliable reports of the use of selected seed, and towards breaking down the conservatism which still exists towards the introduction of new and tested seed.

The customary use of the "tuai" in some places has deterred cultivators from using selected seed, because the crops ripen simultaneously and with one strain Radin No. 7, though good crops are admitted; the straw is rather tough for harvesting with the "tuai". Selected seeds have, almost everywhere, given crops which show comparative resistance to lodging under adverse weather conditions nearing harvest, give better milling returns, and shed less grain than crops grown from unselected seed. Approximately 14,900 gantangs of selected seed were distributed or sold during the year.

Hybridization methods are now also in progress with a view to improving still further the best selected strains. A number of hybrid seeds between the best 3 or 4 strains were successfully ripened after last harvest, but, as the seedlings were growing in the present season, all were unfortunately destroyed by rats, thereby involving the loss of a year with this branch of work.

Manurial experiments continue in Province Wellesley, Krian, Malacca and Kuala Kangsar, and, though definite results are necessarily slow in materialising, fairly definite indications as to the best manures for improving grain yields may be said to be in sight. Wide variation in soil texture and in water facilities render manurial work rather complicated, and the vagaries of our seasons do not assist in the solution of the problem.

Cultural experiments continue in the same centres as the manurial experiments, but the effects of different forms of cultivation are so frequently masked by seasonal conditions that progress is slow. The disadvantages of planting too many seedlings per hill and of too close spacing has been proved; also the efficacy of clean weeding and intensive tillage as compared with haphazard methods and the importance of water control is, of course, well known. Beneficial effects are indicated when land is ploughed immediately after harvest on certain soils, but soils differ so much that it is difficult, as yet, to make specific recommendations.

Catch crops do not yet stand much chance of success since the average cultivator will not yet consider the prospect of tilling his land more than once a year, though possibly cultivators in the Unfederated States may prove more energetic in this direction. There is some chance for the cultivation of early maturing crops on the "batas" in certain areas where they are rich in organic matter, e.g. soya bean and maize in Krian, and this aid towards increasing food crops is being kept in view. Rice storage experiments are proceeding satisfactorily.

The adoption of small power rice mills, as advocated by this Division since 1922 towards maintaining the price of padi, is slowly gaining favour on estates situated within easy distance of regular padi markets, thus encouraging padi production.

Botanical.

The Herbarium of local economic plants was maintained in good condition and numerous plant identifications were made for various applicants.

A study was made by the Assistant Botanist of the bitter Cucumber or Peria (Momordica Charantia) and its varieties. The Peria is highly esteemed locally by Malays, Chinese and Indians as a vegetable, An article containing a full description of the vegetative, flowering and fruiting, characters of the plant, together with information concerning the uses to which it is put was published in the Malayan Agricultural Journal (Vol. XII. No. 2. 1928).

The senior Assistant Botanist, in collaboration with the Secretary for Agriculture, undertook an investigation con-

cerning the plants growing on disused mining areas. As a result the use of certain plants was recommended for trial in the reclamation of lands covered with sand and silt.

GENERAL.

The Economic Botanist visited Kedah, Kelantan and Trengganu early in the year and submitted reports on padi crops in Kedah and Trengganu, together with recommendations for the improvement of rice industry in those States. The Right Hon. Mr. Ormsby-Gore visited the Rice Experiment Station at Titi Serong and the Selection Experiment Station at Klang during the year. The Economic Botanist prepared two papers for the Pacific Science Congress in Java 1929 one on the "Rice Situation In Malaya" and one on "Selection in Coconuts".

H. W. JACK,

Economic Botanist, S.S. & F.M.S.

Kuala Lumpur,
10th January, 1929.

Summary of Padi Returns—British Malaya.

State.		Wet		Dry	
		Acreage	Yield	Average	Yield
		Federated Malay States.			
Perak	...	87,626	19,557,455	6,535	844,443
Selangor	...	13,060	1,669,077	3,579	558,449
N. Sembilan	...	31,555	3,875,692	(includ	ed in wet)
Pahang	...	21,995	3,733,004	7,803	805,436
Total, F.M.S.	...	154,236	28,835,228	17,917	2,208,328
Krian	...	55.182	12,428,774	—	—
		Straits Settlements.			
Singapore	...	—	—	—	—
Penang	...	5,060	2,170,700	—	—
Malacca	...	27,669	8,913,849	—	—
P. Wellesley		39,505	10,942,000	—	—
Dindings	...	600	180,000	470	127,500
Total, S.S.	...	72,834	22,206,549	470	127,500
		Unfederated Malay States.			
Johore	...	3,275	390,181	3,774	854,513
Kedah	...	170,999	53,020,957	1,548	215,205
Perlis	...	32,645	5,434,400	—	—
Kelantan	...	175,312	18,826,980	60	7,200
Trengganu*	...	22,000	2,200,000	8,000	800,000
Total, U.M.S.	...	404,231	79,872,518	13,382	1,876,918
Total, F.M.S.	...	154,236	28,835,228	17,917	2,208,328
,, S.S.	...	72,834	22,206,549	470	127,500
,, U.M.S.	...	404,231	79,872,518	13,382	1,876,918
,, Malaya	...	631,301	130,914,295	31,769	4,212,746

*Estimated by inspection.

Division of Entomology.

ANNUAL REPORT FOR 1928.

Staff.

Mr. H. T. Pagden and Mr. N. C. E. Miller, Assistant Entomologists, reported for duty on the 4th January and the 5th May, 1928, respectively.

PUBLICATIONS.

The following papers were published:—

"Some General Remarks on the Influence of Climatic Conditions on the Prevalence of Economic Insects in Malaya', M.A.J., Vol. XVI, No. 1, January, 1928.

"*Leptoglossus membranaceus* F., a Pest of Cucurbitaceae", M.A.J., Vol. XVI, No. 12, December 1928.

"A list of Parasites and Predators with their Hosts in Malaya", M.A.J., Vol. XVI, No. 12, December, 1928.

A REVIEW OF THE INSECTS OF 1928.

1. INSECTS OF CROPS.

COCONUTS.

(*a*) *Insects of the Inflorescence.*

Tirathaba rufivena Wlk. (The Greater Coconut Spike Moth).

Batrachedra arenosella Wlk. (The Lesser Coconut Spike Moth).

Chelisoches nigronitens St.

Earwigs are always active on the inflorescence and probably feed for the most part on decaying male flowers but no direct damage has been observed.

Diocalandra frumenti F.

This weevil is somewhat similar in its habits to *Chelisoches nigronitens* St.

Derelemorphus eburneus Mshll.

This is another very small weevil which has recently been described by Marshall.

Platydema nuciferae Blair., *Carpophilus foveicollis* Murr. and *Carpophilus dimidiatus* F.

The Tenebrionid, *Platydema nuciferae*, has recently been described by Blair.

Xylotrupes gideon L.

This large familiar beetle, which generally confines its attention to feeding on the undersurface of the petioles causing "leaf-break", has been observed on several occasions feeding on the branches of the inflorescence.

Anathesis laconoides Cand.

Occasional specimens of this click-beetle have been collected from the inflorescence.

Pyroderces ptilodelta Meyr., *Erechthias pavistriata* Wals *Opogona dimidiatella* Zell. and *Stathmopoda adulatrix* Meyr.

Pyroderces ptilodelta is by far the most common.
Haplothrips ceylonicus Schmutz.

This thrips is ever present on the inflorescence and is frequently found inside the opened male flowers probably feeding on pollen.

Mites.

Inflorescences are always covered with mites in exceptionally large numbers.

Oecophylla smaragdina F.

This "keringa" or red ant is the most numerous insect on coconut-palms, frequently webbing the pinnae together.

(b) *Insects of the Leaf and Stem.*

The most important pest of the leaf this year has been the Limacodid moth—*Setora nitens* Wlk. and several reports of damage have been received. Most complaints have been received from the Teluk Anson district and after visiting that area recommendations for its control were made.

Hidari irava Moore.

Occasional reports of injury by the caterpillars of this Hesperiid butterfly have been received but the damage has been confined to small areas. This insect is undoubtedly generally controlled by parasites.

Artona catoxantha Hmps.

The only outbreak of this moth was reported in October from Singapore but rains at the commencement of November were responsible for its termination.

(c) *Miscellaneous Insects.*

The Psychid caterpillar—*Mahasena corbetti* Tams.—caused some damage to young palms and *Amathusia phidippus* L. was recorded for the first time severely injuring one area.

Occasional caterpillars of *Melanitis hypermnestra* L. and *Altha albiguttatus* Snell. were collected.

The Ortalid, *Trigonosoma perilampiforme* Gray., was obtained from a decaying bud and the Dynastid, *Chalcosoma atlas* L., was reported boring the crowns of a coconut palm. The Lyonetiid, *Decadarchis heterogramma* Meyr. was obtained from decaying leaflets of the coconut.

Elaeis Guineensis.

Setora nitens Wlk. was troublesome on one Estate and *Oryctes rhinoceros* L. was responsible for boring the base of petioles.

LEGUMINOUS COVER CROPS AND GREEN MANURES.

Cover crops are liable to the attacks of numerous insects. The most common is the caterpillar of *Lamprosema diemenalis* Guen., *Centrosema Plumieri*, *Clitoria cajanifolia*, *Pueraria phaseoloides*, *Calopogonium mucunoides*, *Desmodium gyroides*, *Dolichos biflorus*, *Tephrosia candida* and *Glycine hispida* have all been observed during the year suffering from the attacks of this insect. Another common caterpillar is the larva of the Lycaenid, *Zizera otis* Fabr. The Pyralid, *Syngamia vibrusalis* Wlk., has occasioned slight damage and the Gracilariid, *Acrocercops caerulea* Meyr. has been recorded mining the leaves of *Vigna catjang*. The following bugs

have been recorded during the year from various covers, *Coptosoma impicticollis* Mont., *Chauliops bisontula* Banks., *Halticus minutus* Reut., *Cyclopelta obscura* Lep., *Physomerus grossipes* F. and *Anoplocnemis phasiana* F.

The beetles, *Pagria aeneicollis* Lef. and *Cneorane modesta* Jac. have also been recorded.

Lampides (Lycaena) boeticus L.

This Lycaenid feeds on the flowers of Leguminosae, *Vigna catjang* in particular. The damage caused by this insect is the complete destruction of the flowers.

Etiella zinckenella Treit.

This Pyralid is another pest of Leguminous seeds.

Etiella has been bred from the seeds of *Tephrosia candida*, *T. toxicaria*, *T. purpurea*, *Crotalaria incana*, *C. striata*, *C. usaramoensis* and *Cajanus indicus*.

An examination of 403 pods of *Tephrosia toxicaria* gave a percentage infestation of 7%.

Parasites. A Braconid parasite—*Chelonus* sp.—has been bred from the larva.

Maruca testulalis Hb.

This Pyralid attacks numerous leguminous plants and may feed either in the seed-pod or on the leaves. It is recorded from seed, flowers and leaves. *Vigna catjang* (seed), *Derris* spp. (flowers and leaves), *Mucuna pruriens* (pods), *Phaseolus multiflorus* (pods) and *Sesbania aculeata* (leaves).

Deiopeia (Utetheisa) pulchella F.

This Arctiid attacks various species of *Crotalaria* and has been bred from both seed-pods and leaves of *Crotalaria usaramoensis* and *C. incana*.

Brachyacma palpigera Wals.

A Gelechiid feeding on seeds of *Tephrosia candida*, *T. hookeriana* and coffee berries.

Araecerus fasciculatus de Geer.

An Anthribid attacking the seeds of leguminous and numerous other plants, both in the field and store. It has been bred from rubber-seed cake, dried areca-nut and Brazil nut, from the seed-pods of *Tephrosia candida*, *T. hookeriana* var. amoena, *T. toxicaria* and *Clitoria striata*, seeds of *Phaseolus vulgaris* and coffee and from the decaying stem of *Carica papaya*.

In the case of *Tephrosia toxicaria* out of 403 pods examined over 25% were attacked by larvae of *Araecerus*, in some cases there were as many as four larvae in a pod.

Coffee.

Extensive defoliation of coffee bushes occurred in Johore by the caterpillars of the hawk moth, *Cephonodes hylas* Linn. An Encyrtid egg-parasite has been recently discovered and possibly is the agent responsible for the termination of outbreaks.

The coffee berry beetle, "boeboek", *Stephanoderes hampei* Ferr. was responsible for boring 90% of the berries on an Estate in Selangor.

Both the beetle, *Araecerus fasciculatus* de Geer, and the Gelechiid moth, *Brachyacma palpigera* Wals., have been bred from berries collected in the field.

The scale-insect, *Coccus viridis* Green., and the Limacodid *Belippa laleana* Mr., have been reported on a few occasions causing damage to the leaves.

Padi.

Leptocorisa acuta Thnbg. caused no extensive damage in the Kuala Pilah area. It was reported in some numbers at Repah, Negri Sembilan, at Kutob, Johore, and a few other places.

Leptocorisa acuta, if conditions are dry, appears to lead a solitary life, but grasses, bursting into flower just before the padi, attract these solitary individuals and if these places are immediately dealt with there is little danger of extensive damage to padi occurring.

Scotinophara coarctata F. occurred in some numbers at Lenggong in Upper Perak and at Blanja, Parit. An outbreak at Kuang was controlled by flooding the fields after heavy rains.

The Jassids, *Nephotettix bipunctatus* F. and *Sogata pallescens* Dist., were received from the Krian district and were reported to cause slight injury. Other insects damaging padi are *Diatraea auricilia* Dudg. and a *Diatraea* sp., *Schoenobius bipunctifer* Wlk., *Sesamia inferens* Wlk. and *Anadastus filiformis* F. The last is an Erotylid beetle. Its larvae feed inside the top internode of the stem. The beetle is generally found on the inflorescence and probably feeds on the pollen.

A nematode worm has been obtained from the moth, *Schoenobius bipunctifer* Walk.

The leaf caterpillars, *Nymphula depunctalis* Guen., *Melanitis ismene* Cram., *Spodoptera mauritia* Boisd., *Cnaphalocrocis medinalis* Guen., *Cnaphalocrocis* sp., *Parnara bada* and *P. mathias* F. and *Telicota bambusae* Moore. have all caused some damage to padi. The caterpillars of *Parnara bada* were found parasitised to the extent of 80% by a Braconid. A Chalcid was bred from *C. medinalis* and an unidentified *Odynerus* sp. was taken preying on the larvae of *Cnaphalocrocis* sp.

An investigation of padi "bugs" other than *Leptocorisa acuta* Thnbg. and *Scotinophara coarctata* F. has been commenced. They are the Coreids, *Riptortus linearis* F., and *Cletus punctiger* Dall. and the Pentatomids, *Menida varipennis* Westw., *Menida histrio* F., *Tetroda histeroides* F., *Nezara viridula* L., *Eusarcoris ventralis* Westw., and *Zicrona coerulea* L.

Croton tiglium.

The Noctuid moth, *Amyna punctum* F. is the principal pest of *Croton*.

An outbreak of *Amyna* may usually be expected in late December or early January and will rapidly increase in severity until the trees are defoliated if no steps are taken. With the first heavy rains, the insect almost completely disappears.

No parasites have been recorded.

NIPAH (*Nipa Fructicans*).

Parasa lepida Cram. has again been prevalent and undoubtedly is the most important enemy to nipah. Hand collecting instead of spraying has been adopted on one Estate. The three Hispid beetles—*Wallacea palmarum* Gestro., *Plesispa reichei* Chap. and *Plesispa nipa* Maulik, have been recorded causing slight damage. *Pyroderces haemodryas* Meyr., has been obtained from the nipah inflorescence and a Pyralid caterpillar has recently been found damaging seedling shoots.

ROSELLE.

Dysdercus cingulatus F. caused great damage to Roselle at Serdang.

Areca catechu (ARECA NUT).

Mahasena corbetti Tams. was occasionally abundant, whilst *Wallacea palmarum* Gestro., by feeding at the base of the young leaves, was responsible for killing occasional plants.

The most important enemy to this crop, however, is an unidentified Capsid bug which sucks the very young flowers causing the eventual discolouration of the fruit.

QUININE.

The most important insect was *Helopeltis cinchonae* Mann. which was responsible for not only dwarfing the growth of quinine in the field but especially damaging seedlings in the nursery.

The hawk moth, *Deilephila hypothous* Cram. was instrumental in causing slight damage to *Cinchona ledgeriana* in the Gardens, Kuala Lumpur.

CINNAMON.

The Cerambycid, *Thermonotus oberthuri* Ritz., the grubs of which bore the trunks of Cinnamon, killed a large percentage of trees on one Estate. Little attention was be-

ing paid to sanitation. The leaf tier, *Cricula trifenestrata* Helf. was also prevalent.

The caterpillars of *Attacus atlas* L., *Lecicoma submarginata* Wlk., *Orgyia mendosa* Hb., *Papilio sarpedon* L., *Pingasa ruginaria* Guen., *Theretra nessus* Dru., and *Avitta rufifrons* Moore, have all caused slight damage.

Camphor.

Lamprosema camphorae sp.n. which Tams described in 1928, joins the edges of the leaf together and feeds inside the fold. The Notodontid, *Stauropus alternus* Wlk. is frequently common on camphor and *Helopeltis cinchonae* Mann. damaged individual seedlings in the nursery at Cameron's Highlands.

Aleurites Montana (China Wood-Oil).

Although numerous leaf-eating insects have been recorded on this plant, little damage has taken place. Probably the most common are the Limacodids, *Miresa albipuncta* H.S. and Parasa *lepida* Hbn. The Psychid, *Mahasena corbetti* sp.n. and *Nygmia corbetti* sp.n. which have also been recorded are new species described during the year by Tams. The Geometrid, *Boarmia transcissa lineataris* Wlk. has recently been recorded on this plant.

Tea.

The principal insects recorded during the year under review are the Capsid bugs, *Helopeltis cinchonae* Mann. and a *Helopeltis sp.*, un dthe aphid, *Toxoptera aurantii* Boyer.

Gambier.

The leaves of this plant are attacked by the Pyralid leaf-roller—*Margaronia coeruleiceps* Hamps. The hawk moth, *Deilephila hypothous* Cram., also is frequently much in evidence feeding upon the leaves and causing considerable defoliation. *Attacus atlas* L. has been occasionally found whilst the Capsid bug—*Helopeltis* (?) *sumatrana* Rpke. is sometimes in evidence sucking the young shoots.

Unidentified Sesiid borers causing considerable injury to the branches were observed in one area in Johore.

Palaquium gutta (GUTTA-PERCHA).

The caterpillars of *Suana concolor* Walk. have been reported damaging the leaves of individual plants. The most important pest however is the leaf-rolling caterpillar of *Rhodoneura myrtaea* Drury. Occasionally *Sylepta balteata* F. causes some damage.

Extensive damage has been occasioned by a *Helopeltis* sp. killing the young leaves and causing leaf-drop. This insect is generally prevalent during the wetter months of the year.

A weevil—*Alcides* sp.—has been found damaging the collected seed of gutta-percha.

Hydnocarpus anthelminthicus and *Wightiana*

(CHAULMOOGRA OIL).

The Limacodid, *Altha albiguttatus* Snell., has been collected feeding on the leaves of the former and *Belippa lohor* Moore, on the latter plant.

Zeuzera coffeae Niet. was found on several occasions at Serdang boring the branches of *wightiana* and was successfully treated by the application of Carbon bi-sulphide.

Derris ("TUBA").

The toxicity of *Derris* spp. has been under investigation. Records of the following additional insects damaging *Derris* have been made, *Eucosma conciliata* Meyr., *Eucosma balanoptycha* Meyr., *Mocis undata* F. and *Homona coffearia* Nietn.

MAIZE.

Scotinophara coarctata F. This Pentatomid is found particularly on *Oryza sativa* but also on *Zea mays*. A Chalcidoid egg-parasite has been obtained but has not been identified.

Phenice (Proutista) moesta Westw. A Derbiid foud on the leaves of *Zea mays, Oryza sativa, Cocos nucifera, Elaeis guineensis, Saccharum officinarum,* and *Cymbopogon nardus* and probably many other plants. Its nymphal stages are said to be passed in rotten wood.

Peregrinus maydis Ashm. A Delphacid on Maize which feeds in all stages on the young stems and the upper surface of the leaves is occasionally numerous.

Pyrausta salentialis Snell. This Pyralid is recorded from both stem and cob of maize, and in India is said to bore a species of *Polygonum.*

Pyroderces amphisaris Meyr. A Cosmopterygid attacking both inflorescence and cob of maize.

(ii) *Insects of Fruit Trees.*

Citrus.

Oranges were attacked by the Coreid, *Leptoglossus membranaceus* F., and the Pentatomid, *Rhynchocoris humeralis* Thnbg. A visit was paid to the Government Experimental Plantation where the former insect was found breeding on native grown cucurbits close to the orange trees. The cucurbits were removed and no further reports of *Leptoglossus* damaging oranges there have been received. *Rhynchocoris humeralis* Thnbg., was comparatively few in number. A visit was paid to Selama, Perak North, to investigate the cause of damage to oranges in that district. Numerous fruits had previously been received from which *Drosophila lurida* Walk. and *Drosophila* spp. emerged. The cause of the damage was found to be the Trypetid fly, *Chaetodacus ferrugineus* F. A poisoned bait and fumigation of the ground together with the burning of all infected fruit were recommended.

Work on *Prays endocarpa* Meyr. has been carried out throughout the year but success in breeding it through from egg to adult either in the laboratory or when caged on trees has not been obtained. A Chalcidoid parasite has been obtained from citrus fruits infected by *Prays.* Two parasites—one a Braconid and the other a Tachinid—have been recorded.

Drosophilids, among which *Drosophila lurida* Walk, is probably as numerous as any other species, emerge in large numbers from fruits attacked by *Chaetodacus*.

The Pentatomid, *Rhynchocoris humeralis* Thnbg. has been found on orange fruits, the Fulgorids, *Ricania pulverosa* Stol. and *Dictyophara pallida* Don. on the shoots of lime and orange, and the Coreids, *Riptortus linearis* F. sucking lime flowers and *Mictis tenebrosa* F. sucking the young shoots of limes. Occasional caterpillars of *Papilio achates* Cram. on the leaves of limes and pomeloes have been collected but the principal caterpillar pests are *Papilio demoleus malayanus* L. and *Papilio polytes* L.

Papilio helenus L. was collected on lime bushes at an altitude of 1900 feet. The Noctuid, *Parallelia palumba* Guen. was recorded on Pomelo for the first time.

The weevil, *Phytoscaphus leporinus* Fst. caused slight damage to flowers of lemons but *Hypomeces squamosus* F. was occasionally responsible for considerable injury to the leaves.

Musa Sapientium (Banana).

The leaf-roller, *Erionota thrax* L., was conspicuously prevalent throughout Malaya but no instance of its causing the death of the plant has been recorded. The caterpillars are frequently heavily parasitised by the Braconid, *Apanteles erionotae* Wilkn. The weevils, *Odoiporus longicollis* Oliv. and *Cosmopolites sordidus* Germ. have been found responsible for killing bananas, but although widely distributed seem to cause less injury in Malaya than elsewhere. The Arctiid, *Creatonotus transiens* Walk., and the Noctuid, *Prodenia litura* L., have been reported causing extensive damage in different areas. An enquiry concerning the Tingid, *Stephanitis typicus* Dist., has been received. In one area it was alleged to have inflicted serious injury.

Anona Muricata (Soursop).

The caterpillar of *Papilio agamemnon* L. has caused a certain amount of damage but *Attacus atlas* L. has been the major pest.

Achras Sapota (Chiku).

This plant is generally free from insects. *Rhodoneura myrsusalis* Walk., which is commonly met with on *Bassia latifolia* was found in some numbers damaging the leaves. The Trypetid, *Chaetodacus ferrugineus* F., has frequently been found damaging the fruits.

Psidium Guajava (Guava).

Attacus cynthia Dru. was found causing much damage on one occasion to this plant. *Attacus atlas* L. was also recorded from this plant and *Persea gratissima* (Avocado pear) during the year. *Chaetodacus ferrugineus* F. was bred from the fruits of the first named-plant.

Nephelium Lappaceum (Rambutan).

Considerable damage was done by the night-flying beetles, *Apogonia cribricollis* Burm., *Lepadoretus griseosetosus* nofr. and *Chaetadoretus bornensis* Kraatz.

(iii) Insects on Other Plants.

(a) *Vegetables.*

Tomato.

The fruit-fly, *Chaetodacus ferrugineus* F., has been the subject of enquiries. The Eel-worm, *Heterodera radicicola*, has been an agent causing the withering of plants.

Ipomaea Batatas (Sweet Potato).

The Coreid, *Homoeocerus serrifer* Westw., was collected damaging the shoots and stems of sweet potato and groundnut at Serdang. *Physomerus grossipes* F. was also commonly found on this plant. The caterpillar of *Omphisa anastamosalis* Guen. caused some damage to one area. The Pterophorid, *Alucita niveodactyla* Pag., was recorded for the first time. The weevil, *Cylas formicarius* F., inflicted severe damage to the tubers in one area.

Solanum Melongeanum (Brinjal).

The ant, *Solenopsis geminata* F., destroyed buds and shoots whilst the coccinellid, *Epilachna indica* Muls., the

Chrysomelid, *Rhaphidopalpa similis* Oliv., and the Pyralid, *Psara bipunctalis* F. were found feeding to a slight degree on the leaves. The principal pest, however, recorded during the year was *Leucinodes orbonalis* Guen.

The Coreid, *Anoplocnemis phasiana* F., by sucking the sap from young shoots inflicted slight injury and the Gelechiid, *Phthorimaea ergasima* Meyr. was obtained from the leaves.

Cucurbitaceous Plants.

Probably the most injurious insects to these plants which include Wax gourd, Snake gourd, Cucumber, Pumpkin, Loofah and Carilla have been the fruit flies, *Chaetodacus caudatus* F. and *cucurbitae* Coq. Both these Trypetids seem to confine their attention entirely to the fruits of cucurbitaceous plants causing considerable damage. No parasites have been bred with the doubtful exception of a Tachinid. Insects damaging the leaves have been the beetles *Ceratia coffeae* Hornst., *Rhaphidopalpa similis* Oliv. and *Ceratia atripennis* F., the two former were also obtained at Cameron's Highlands.

The Reduviid, *Sycanus leucomesus* Walk., has been found feeding on these beetles.

The Coreid, *Leptoglossus membranaceus* F., has been numerous on several occasions at Serdang on *Cucurbita maxima*, *Luffa acutangula*, *Momordica charantia*, *Trichosanthes anguina* and *T. palmata*.

(b) *Flowering Plants.*

Canna.

The insects causing most damage to the leaves are the beetles *Lepadoretus compressus* Weber., *Apogonia cribricollis* Burm. and an *Autoserica* sp.

The caterpillars of the Sphingid—*Acherontia lachesis* F. and the Arctiid—*Amsacta lactinea* Cram. are occasionally troublesome.

Zephyranthes and *Crinum*.

The blackish-white banded caterpillars of *Brithys crini* F. mine the leaves of the last-mentioned and feed on the

stems below the surface of the ground. Persistent hand-picking and, if necessary, spraying with lead arsenate should be practised.

Gardenia.

The slug-like caterpillar of *Altha albiguttatus* Snell. has occasionally occurred but the hawk moth *Cephonodes hylas* is more common.

Hibiscus.

Sylepta derogata F., the caterpillars of which roll the leaves, *Xanthodes transversa* Gn. and *Anomis flava* F., the caterpillars of which feed exposed on the leaf.

Dysdercus cingulatus F. A case of entire defoliation was due to an *Aleyrodid* (*Aleurocanthus* sp.) and mites prevented the normal unfolding and caused "blistering" of the leaves.

Coccids are always conspicuously present.

ORCHID.

The white frothy secretions of the larvae of the beetle *Lema pectoralis* Baly. have attracted attention and enquiries have been received. The Geometrid caterpillar, *Boarmia fuliginea* Hamps., has been noted on the leaves.

(c) *Ornamental.*

Casuarina.

In addition to scale insects, the Fulgorid, *Lawana conspersa* Wlk., occasionally occurs in enormous numbers. The needles of the *Casuarina* are frequently bound together by the larva of *Agylla gateri* Tams. The very large caterpillars of *Streblote lipara* Tams. have been recorded on one occasion causing extensive damage to the needles of this plant.

Mesua Ferrea (Ceylon Iron Wood).

The Noctuid caterpillars of *Stictoptera subobliqua* Wlk. and *Simplicia marginata* Moore, have occasionally been collected.

Cassia Fistula.

This ornamental plant suffered considerably from the attacks of the caterpillars of *Catopsilia pomone* F., *C. crocale* Cram., *C. pyranthe* L. and *Terias blanda* Boisd., on one occasion entirely defoliated some plants.

Enterolobium Saman (Rain Tree).

Considerable injury was caused to this shade tree by caterpillars of the Noctuids, *Rhesala figurata* Moore. and *R. imparata* Wlk.

(iv) Insects of Stored Products.

Diocalandra (*Calandra*) *oryzae* L.

Silvanus surinamensis F.

Tenebrionoides mauritanicus L.

Tribolium castaneum Hbst. A Tenebrionid recorded from rubber-seed cake, stored Derris and rice.

Lasioderma serricorne F. This Anobiid is a serious pest of stored products, notably tobacco and cheroots.

Bruchus analis F. and *Bruchus obsoletus* Say. The former has been recorded from *Phaseolus radiatus* and *Cajanus indicus* and the latter from *Phaseolus vulgaris*.

Sitotroga cerealella Ol.

Dermestes vulpinus F. This Dermestid is universally distributed. It has been bred from preserved fish imported from China.

Trichophaga abruptella Woll. The larva of this Tineid has been recorded feeding on cloth and carpets. It is frequently responsible for damaging the cloth upholstering of cars.

Miscellaneous.

Martesia striata Linn. This Mollusc was found in timber at a wharf in the Straits Settlements.

Achatina fulica. Interest has been shown in this during the year and in addition to other places it has recorded from Johore and Kelantan.

Thalassina anomala. This crab causes extensive damage to estate roads, drains and bunds in coastal areas. Poison baits have been tried with indifferent success.

Cheiromeles torquatus. This bat known to the Malays in Pahang as "Kelasar" was reported damaging padi by severing the ears. This bat is undoubtedly insectivorous. The examination of specimens revealed the presence of a few lepidopterous scales, the reactions for starch and hydrolysed cellulose were negative whilst the reaction for chitin was weak positive.

Ants in houses. During the year the well-known Argentine ant poison has been tried and on every occasion has proved successful in freeing houses from ants.

General.

An enquiry outside Malaya was received concerning the insects attacking *Solanum torrum* with a view to their possible introduction to control this weed in that Country. It was natural to find that its pests in Malaya were the same as those of the closely related plant, brinjal (*Solanum melongeanum*).

Leucinodes orbonalis Guen., *Epilachna indica* Muls., *Dacus ferrugineus* F. were recorded and it was hoped that *Phthorimea ergasima* Meyr., whose caterpillars bore the seed might be worthy of consideration to import, since about 60% of the berries were found to be attacked. Our records, however, show that the caterpillars of this moth—*Phthorimea ergasima* Meyr. mine the leaves of brinjal and also live inside the fruits of *Solanum verbascifolium* but it cannot be considered a pest in Malaya.

Information was also sought with regard to the parasites of *Tirathaba rufivena* Wlk. (The Greater Coconut Spike Moth) with a view to their possible importation. The recorded parasites in Malaya are the Ichneumonid, *Nemeritis palmaris* wilkn. and the Tachinid *Hemimaticera basifulva* Bezzi.

(Sgd.) G. H. Corbett,

and S *Government Entomologist, S.S. & F.M.S.*

lected. arch, 1929.

Field Division.

ANNUAL REPORT FOR 1928.

I. STAFF.

Mr. F. Birkinshaw from January 16th to June 28th and Mr. A. E. C. Doscas from June 29th acted Chief Field Officer vice Mr. F. W. South, acting Secretary for Agriculture.

Mr. J. Fairweather acted Agricultural Field Officer, Perak North, from June 29th vice Mr. F. Birkinshaw on leave.

Mr. F. R. Mason acted Principal Agricultural Officer, Johore, from April 6th to November 30th inclusive vice Mr. F. de la Mare Norris on leave. He acted Agricultural Field Officer, Perak South from December 5th vice Mr. Doscas. Mr. J. W. Jolly acted Agricultural Field Officer, Province Wellesley and Penang from April 6th vice Mr. Mason.

Mr. C. L. Newman took up the appointment of Agricultural Field Officer, Selangor, from January 1st vice Mr. R. B. Jagoe transferred to the Economic Botanist's Division. He acted Agricultural Field Officer, Malacca, from July 1st vice Mr. Fairweather.

Mr. J. A. Craig acted Agricultural Field Officer, Perak South, from June 5th and Agricultural Field Officer, Selangor, from December 5th.

Leave.—Mr. F. de la Mare Norris April 6th to November 30th and Mr. F. Birkinshaw from June 28th.

II. ESTATES VISITED.

Area.	Estates.	By request.	Visited more than once.
Selangor -	18	10	5
Negri Sembilan -	8	1	1
Perak North -	5	5	1
Pahang West -	4	4	1
Perak South -	10	1	6
Penang & P. Wellesley	15	11	6
Malacca -	10	9	...
Johore -	163	17	11

The majority of estate inspections were for the purpose of control of pests and diseases. Other visits were connected with the cultivation of Oil Palms, miscellaneous food crops, coconuts, tuba root, tea, coffee, bananas and tapioca; the purchase of an orchard by Government, applications for land, identifying indigenous cover crops, leaf fire damage, export certificates for budwood, destruction of dead coconut palms, destruction of land crops, introduction of good strains of padi, export of rubber seed and collection of soil samples.

III. Rubber.

(i) *General.*

It is of interest to record that although the atmosphere of uncertainty caused by the announcement early in the year that restriction would cease on October 31st. enforced a programme of rigid economy, the general maintenance of larger properties was well maintained, while the judicious distribution of coupons corrected any tendency on the part of small holders to disregard their responsibilities. Since the passing of the coupon however a general decline in the standard of maintenance has become apparent in small holdings throughout the country, while disease control has become increasingly difficult to enforce.

An American Oil Corporation interested in the manufacture of rubber seed oil created a market for rubber seeds in this country during the latter half of the year. The Corporation's decorticating plant is situated in Sumatra, but should sufficient support be lent to the venture by Malayan cultivators it is proposed to establish a local plant, in which event small holders will be enabled to participate. Owing to strict import regulations prevailing in the Dutch East Indies, a considerable quantity of material forwarded to Port Swettenham and Prai could not be passed as conforming to the standard set by the Dutch authorities, although acceptable to the Corporation for their purpose. A total of 122,178 bags were exported.

Very large quantities of budwood, budded stumps and selected seeds have been imported from Java and Sumatra

throughout the year. See Appendix A. Small quantities of seed and budwood have also been exported.

(ii) *Pests and Diseases.*

Tapping surface.

(a) *Mouldy Rot*—(*Ceratostomella fimbriata*, Ell. & Halst. (Elliott).

Dry weather generally during the first eight months of the year acted as a check to the development and spread of this disease. The general rains experienced during September however, produced prolific outbreaks in all areas where the disease had previously been established. The staff of the division has been severely taxed in endeavouring to regain control since the abolition of restriction. The universal eagerness to obtain maximum output requires the closest supervision in order to have cessation of tapping observed as an essential measure of treatment.

Black Stripe Phytophthora spp.

A few cases only of this disease were reported during the third quarter at Gombak in Kuala Lumpur district, and in the Kinta district of Perak. During the last quarter however Perak South became the centre of a wide-spread attack embracing the districts of Kinta, Batang Padang, Lower Perak and Sitiawan. The most virulent infections were centred in the Kinta district but yielded to prompt and efficient treatment. In the riverine mukims of Lower Perak an extensive infection was located. Lack of staff and easy transport, together with considerable flooding during December rendered supervision and control very difficult.

Collar Patch Canker (*Pythium* sp.)

This disease was present during the year on an estate near Batu Gajah. Treatment which included the destruction of some of the attacked trees was quickly put in hand and the disease controlled.

(b) *Stem Diseases* (*Corticium salmonicolor* B. & Br.)

Cases were reported from Perak, Selangor and most districts in Pahang West and three estates reported the presence

of the disease in Johore. The conditions in small holdings calls for no special mention.

Stem Canker.

A somewhat severe affection of young plants in a new clearing on Mentakab estate was investigated by the Rubber Research Institute.

(c) *Root Diseases (Ustulina zonata).*

This disease is reported to be very prevalent in the Muar district of Johore, and in the vicinity of the Pahang River in low lying and damp situations.

Fomes pseudo-ferreus and *Fomes lignosus.* Is fairly generally distributed throughout old established planted areas in each State, more especially Johore, Selangor and Perak.

An increase in the number of small holders devoting attention to the treatment of root diseases is generally reported.

IV. Coconuts.

(i) *General.*

With the exception of Johore and to a lesser extent Malacca, no appreciable expansion of planted areas has been reported during the year. In Johore exports have been well maintained, and are in excess of those for 1927. Extensions to planted areas have been made along the west coast.

The necessity of restocking the flood devastated areas of riverine mukims of Pahang is being urged, and every assistance given towards achieving this end.

(ii) *Pests and Diseases.*

Setora nitens Walk.

An outbreak of this pest was reported during July on three adjacent coconut estates in the Bagan Datoh district of Lower Perak. Young palms were attacked first and later older palms were invaded. The Assistant Government Entomologist visited the area at the end of July and suggested methods of treatment and control which took the form of hand picking the caterpillar from young palms, and spraying

those which could not be reached by hand. The outbreak suddenly ceased, and large numbers of dead caterpillars were found on and below the young palms, and it was considered that parasitism was largely responsible for the eradication of the pest. Further outbreaks occurred during September and November and were successfully controlled by hand picking.

During the first quarter this pest was found over a large area on an estate in Selangor on the Bernam river, and was successfully controlled by spraying with lead arsenate.

Marasmius sp. was again responsible for damage on a dwarf coconut estate in Perak North.

The affection known in Johore as Benut disease has not been so prevalent in the Benut and Kukub districts. Burning or burying attacked palms and the establishment of isolation trenches in diseased areas has been maintained.

Artona catoxantha, Hamps. Two outbreaks were reported from the South coast of Johore. The most serious attack was not discovered until considerable damage had been experienced, and the pest controlled by parasites.

Black Beetle (*Oryctes rhinoceros*). This pest is still prevalent in the vicinity of townships and villages where control measures are enforced during the ordinary routine inspection duties of the staff.

V. Padi.

(i) *General.*

(a) *Season 1927—28.*

With the exception of Malacca and Pahang West unfavourable weather conditions reacted against crops and yields are below average.

In Larut and the mukims of Selinsing, Semanggol, Parit Buntar, Brieh and Bagan Serai in Krian districts, and in parts of the Province harvesting was accompanied by rain with consequent loss.

In Pahang West the planted area was in excess of that of the previous season to the extent of some 7,221 acres. In many cases the flood detritus proved to be fertile and very suitable for padi cultivation, and good yields were obtained.

In Pahang East a severe drought lasting into September delayed planting, and floods during December did considerable damage to unharvested areas. Where the grain had set it is estimated that eighty gantangs will be obtained from damaged areas, but where the crop was immature a total loss will be sustained. 592 acres are reported to be harvested or undamaged, 935 damaged, and 519 destroyed.

Malacca experienced a satisfactory season and obtained average yields.

(b) *Season 1928—29.*

Unfavourable planting conditions were again experienced in the principal padi planting areas. Once established however the crops made favourable progress and prospects at the end of the year were better than anticipated earlier in the season.

Perak.—In Perak North prospects are considered to be good. Lack of rain and the low level of water in irrigating channels resulted in wide variations in the planting programme which was not complete till mid December. In Larut planting was late but the crop has made good progress Prospects in Kuala Kangsar are fair and with the exception of sawahs at Blanja and Saiong where extensive rat damage was experienced, crops should be up to average. The crop in Upper Perak is reported to be looking exceptionally well.

In Perak South the area planted is larger than in previous years with the exception of the riverine mukims of Lower Perak. Considerable expansion is reported from Kwang in Kinta district where new areas have been brought into cultivation. At Tanjong Malim the planting programme was up to time and practically all areas were cultivated. Owing to seed shortage in Lower Perak 929 gantangs of "Radin 2" and 50 gantangs of pulut were distributed in the river mukims; upkeep however was not good and rats did considerable damage. Flooding took place towards the end of the year but damage if any is not yet known. Work was well in hand in Batang Padang, and crops forward. Rain in November damaged an extensive area of hill padi.

Selangor.—Transplanting commenced in June but where irrigation facilities were lacking considerable delay ensued. As a temporary flood preventive measure the P.W.D.

"degraded" the irrigating stream in the Ulu Yam area causing much silting of padi land, and the loss of some fifty acres of crop.

Negri Sembilan.

With the exception of the Muar river valley planting was up to time and quickly concluded. Three to four months padi was planted in the latter areas. A new dam at Pantai was finished during the year and an extensive of cultivation in this area is anticipated. An increased area under cultivation is reported from Port Dickson where good crops of hill padi have been harvested.

Pahang.

Gloomy reports of the conditions in the river mukims of Pahang West have been received. Continued shortage of water resulted in late planting, scorching and a heavy pest incidence, and it is considered that yields will be decidedly inferior to the 1927—28 harvest. Several mukims have planted up areas of maize, tapioca and other food products to meet the shortage. The road mukims however, especially Ulu Cheka, Tanjong Besar and Budu in Lipis district, and Dong and Sega in Raub have made very satisfactory progress and yields will probably eclipse those of the previous season. At the end of the year harvesting was in progress in Temerloh and Bentong districts and many mukims of Lipis district. News of a serious flood was to hand on December 27th, and it is understood that many areas below Kuala Tembling have been badly flooded and it is anticipated that considerable loss will be experienced in areas where harvesting was not completed. Conditions in Pahang East were dealt with under the heading Season 1927—28

Province Wellesley.—Planting was very late, but the crop has made good progress and prospects at the end of the year were encouraging.

Malacca.—An increased area is reported to be under cultivation, prospects are good and flood damage negligible.

Johore.—Increased interest in padi cultivation is maintained and a steady extension of planted areas reported. Comparatively large areas have been planted at Kota Tinggi and Segamat, while dry padi has been extensively planted between coconuts and areca nuts around Batu Pahat and Muar.

Good progress has been made at the padi area near Mersing where facilities to irrigate some three hundred acres are nearing completion. Satisfactory progress is reported from Ayer Papan where selected varieties have been planted.

(ii) *Pests.*

Mole crickets. *(Curtilla africana)* attacked nurseries at Redang and Ketior at Parit in Perak.

Scotinophara coarctata. An area at Layang Layang in Perak where water control was not available was damaged beyond recovery by this insect. A certain amount of damage was reported from Pahang East while at Rantau Panjang mukim Semantan, and Tok Embun mukim Mentakab, Temerloh district; and at Gandong, mukim Benjom, and throughout mukim Ulu Cheka in Pahang West the pest was also established but quickly controlled by flooding without much damage, except at Tok Embun where water was not available. The pest also appeared in considerable numbers at Kuang in Selangor but was almost immediately controlled by heavy rains.

Sogata pallescens was present in various areas in the district of Krian. Attacked plots were drained and kept dry for several days and the pest quickly disappeared. Damage at Kajang Paya in Selangor was minimised by similar treatment.

Leptocorisa acuta appeared in large numbers at Senaling in Kuala Pilah district. The cultivators were turned out by the District Officer, and under the supervision of officers of the division the pest was eventually controlled.

Sesamia inferens and *Diatraea auricilia* were responsible for extensive damage at Beranang and to a lesser extent at Kuang and Kampong Kuala Pajam in Selangor. They were also present at Tanjong Malim in Perak South.

(iii) *Organised Rat Destruction.*

(a) *Krian.*

The campaign in this area has been energetically pursued, and damage to padi is reduced to a minimum. The following table shows the catches for 1927—1928.

		1927.	1928.
Cultivators	...	256,906	536,493
Schools	...	333,617	318,719
P.W.D.	...	252,262	49,432
		842,791	904,644

(b) *Province Wellesley.*

Since the appointment of a Rat Destruction Officer on July 23rd., the work in this area has yielded very encouraging results. Regular and prompt payment for tails appears to be an essential factor, otherwise interest quickly flags, and catches rapidly decrease. The services of a whole time officer meets this requirement, while general supervision and organisation are maintained.

Schools and Tamil road coolies have yielded the largest proportion of catches. Up to the present participation in drives has made no appeal, but attempts to popularise this form of destruction will be continued.

The Agricultural Field Officer reports that rat damage in nurseries was not excessive and that since transplanting damage has been scattered and only over a limited area It is the general opinion of cultivators that the campaign has greatly reduced damage by rats.

During the year 509,151 tails were paid for, the average cost working out at 1.785 cents per tail.

VI. Minor Crops.

Oil Palm.—Continued interest is being shown in this crop and increased developments especially in Johore, Perak, and possibly Pahang may be confidently anticipated.

Coffee.—Areas under this crop are reported to be in good condition and yielding satisfactory returns. Increased interest is reported from Pahang East and the Dindings. In Johore the crop is now fairly extensively cultivated the principal centre being Paloh.

Cloves.—The cultivation of this crop in Penang is considered to be diminishing.

Pineapples.—In Johore satisfactory crops have been obtained and output for the year is in excess of previous years with the exception perhaps of 1925. Three new factories were in course of erection during the year.

Interest in this crop in Selangor is centred around Klang where a local factory absorbs the bulk of the crop. Prices however are usually low.

Tapioca.—Production in Johore shows a slight increase. It is extensively grown as a catch-crop with rubber. Enquiries have been received as to its suitability as a catch crop with African oil palm, fruit trees, coffee etc. A new factory has recently been opened at Kulai.

Tea.—Three small areas in Negri Sembilan are producing a low grade product. An area of approximately 150 acres is cultivated by Chinese gardeners in Selangor, and three grades are put up for local sale. No further extension of cultivated areas has been reported, but preparations are being made for production on a large scale in Selangor, while enquiries in Pahang have also been made.

Tuba.—Former plantings in Johore River area are gradually being removed. The main areas are now situated at Layang Layang and Senai. About 250 acres are interplanted with rubber in Negri Sembilan. Fairly considerable areas are still cultivated in Perak South.

Gambier.—Although this crop is still attracting attention in Johore, areas in other States notably Negri Sembilan and Pahang West are being cut out, as a result of low prices ruling.

Areca Nut.—An increased output is reported from Johore where comparatively large extensions have recently taken place.

Bananas.—Considerable areas of this crop are established in Negri Sembilan, Selangor and Perak, where it is used as a catch crop.

Vegetables and food crops.—A considerable extension of areas under miscellaneous food crops is reported from Perak South where quantities of seed have been obtained by the department and sold to cultivators at cost price. Areas in Pahang East are uniformly bad.

Sago.—An appreciable export of sago is still maintained from Johore but areas of the palm have recently been cut out in the Kukub district.

Fruit.—The mid season fruit crop was satisfactory throughout, but towards the end of the year, due no doubt to unfavourable weather, crops generally were extremely poor and sparsely represented in the markets.

VII. Miscellaneous Pests and Diseases.

Water Hyacinth (Eichhornia crassipes).

The departmental gang of coolies was employed on the lower reaches of the Perak river during the period April 23rd July 28th. All traps in Perak South have been well maintained throughout the year.

In Perak North the gang was employed in the Krian irrigation area during January and February, and up to the time of transfer to Perak South was engaged in work around Taiping. From the end of July to the close of the year the Krian district was dealt with.

The departmental gang in Province Wellesley was employed throughout the year and effectively controlled the pest throughout that area.

Giant Snail. (Achatina fulica).—There was no particular activity during the dryer periods of the year. An increase is reported from Ipoh while Teluk Anson and Batu Gajah have also become infested. In Selangor the snail has been reported from Kuala Lumpur and Rasa, while it has also appeared in Kuala Lipis in Pahang. It is now well established in Johore Bahru, and has also been reported from Muar and Kota Tinggi, having been introduced into the latter place on pot plants brought from Singapore.

Lallang and Blukar.—While the coupon was in vogue a very satisfactory maintenance was achieved. During

August however a decision in the Supreme Court of the Straits Settlements ruled, that Lallang and Blukar did not constitute a pest within the meaning of the Ordinance. Pending a settlement of this point of law no further action has been possible., and the general position at the end of the year was extremely unsatisfactory.

Panama Disease.—Panama disease of bananas has been confirmed from Jelebu in Negri Sembilan, and Tapah in Perak South.

VIII. Experimental Stations.

(a) *Padi Stations*.

Perak. Talang Test Station, 1927—28.—The yields throughout the station of Seraups No. 1, 15, 36, 48, 52, were very satisfactory and varied from 480 gantangs per acre for Seraup No. 15 to 735 gantangs per acre for Seraup No. 1. The highest yield obtained from unselected seed in the immediate vicinity of the station was 350 gantangs per acre.

Radin 13 which was planted as the main crop gave a mean average yield per acre of 527 gantangs.

Serendah 741 yielded only 365 gantangs per acre.

1928—29. The same planting scheme has been adhered to. Manurial trials have been extended.

Pahang. Dong Station, 1927—28.—Very satisfactory results were obtained and valuable information recorded.

1928—29. This crop looks extremely promising and and should eclipse the results of the previous season. Seraup Kechil 36, and Padi Negri, the former from Krian and the latter a local padi have displaced the two Malacca foundation stocks 824 and 746 in this year's planting. During 1929 it is hoped to commence distribution of approved stock, together with preliminary selection work on proved local varieties.

Arrangements are being made for the establishment of a test station at Temerloh where an area has been provisionally chosen for this purpose.

Pekan Station.—Work on this station was greatly hindered by dry weather. Transplanting of wet padi was delayed until the end of July owing to previous failure. The dry padi was sown at the end of June, and has made fair progress. On the dry padi plots grass cuttings and vegetable rubbish was applied to the land a month before ploughing and was then thoroughly incorporated in the soil in three ploughings. The object of this treatment was to test whether such rufuse so easily obtainable was of sufficient manurial value in itself. The results so far are very encouraging; a fair stand of padi being obtained, while tilth is much improved.

A slight departure was made from following local methods as far as possible in the case of wet padi. This was to ascertain if wet conditions after the grain had set had any influence on the longer maturation period of certain padis in Pahang East. In the case of Nachin Puteh grown from seed obtained in 1927 from Malacca, where it is a six months variety, under local conditions of husbandry was found to be six months and twenty seven days. This year however the plots were drained when the grain had swelled, and the crop was harvested in exactly six months.

Damage by flood was again experienced.

Province Wellesley. Pekan Darat Station.—The 1928—29 Crop is being conducted along the same lines as previous years. The appearance at present is reported to be fair, but certainly better than surrounding areas. Arrangements are in hand to obtain a more suitable area, as water control on the present station is very unsatisfactory.

Glugor Tests.

The management of Glugor estate, Penang, undertook to test selected strains of padi on their sawah land. The work was well conducted and two relongs were planted with seed supplied by the Economic Botanist and consisting of Seraup Kechil Nos. 36, 48, 15, and Radins Nos. 2, 4, 7, and 13. Surplus nursery stocks were distributed to adjacent cultivators, and the total area planted with selected seed amounts to some twenty relongs.

Malacca. Pulau Gadong Station.—1927—28. The crop was badly damanged by rats and no conclusions could be

drawn from the figures obtained. The Pure Lines however were not affected, and the usual records were obtained for the third year.

1928—29. The crop has done fairly well so far. Acid water flooding in from adjacent swamp land caused a considerable set-back to the whole station.

Selangor.—Small experimental plots have been conducted during the year at Kajang Paya, Bukit Cheraka and Tanjong Karang.

Radin No. 13 and Seraup No. 36 were planted at Kajang and have made good growth. The plots suffered damage from stem borers.

At Bukit Cheraka where Seraups Nos. 36, 15, and Radin Nos. 7 and 13 were planted, unfavourable conditions, and neglect by the contracting cultivator have combined to render valueless any results that may be obtained.

A salt resisting variety from Kedah was planted at Tanjong Karang but was completely destroyed by flood.

(b) *Other Stations and Experiments.*

Kuala Kangsar Fruit Station.—A crop of approximately 16,000 oranges was harvested and sold for $170.

A few selected varieties of Rambutan, Pulasan, Pomelo and Chiku were planted towards the end of the year. Cover crops have been retained for seed purposes, and green dressings for Talang padi station.

Talang Coconut Station.—As dwarf coconuts were making slow progress on this station it was decided to replace them with a selected tall variety. The cover crop of *Mimosa invisa* was dug in, and the land cleared limed and changkolled ready to receive the new material.

Green Dressing Experiments on Slimed Land.—*Tephrosia candida* and *Mimosa invisa* continued to make good growth throughout the year.

Negri Sembilan Fruit Station.—The unplanted portion of this station, which is on a slight slope, has been cleared, bunded, and planted with various cover crops.

The budding of citrus on pomelo stock was commenced during the year, but was not successful owing to dry weather.

Kuala Lipis Fruit Station.—Soil improvement by green manuring, and the laying down of a necessary drainage system were attended to during the year. Citrus trees are reported to be doing well although requiring much attention to cope with pests. The station was almost completely submerged on December 27 and 28.

The experimental work on cultural operations connected with the management of cover crops in Perak South has been maintained. Girth measurments are taken every three months, and moisture determinations taken from time to time.

IX. Other Instructional Activities.

The Agricultural Field Officer, Pahang East delivered lectures at the Pekan and Kuantan clubs on the subject of garden soils. Short lectures were also given to school children.

In Temerloh an inter-kampong competition inaugurated by the District Officer was a distinct success. Prizes were awarded for the best vegetable garden, combined with cleanliness and sanitation of dwellings.

School Gardens.—Routine inspections have been carried out during the year and members of the staff have acted as judges in several competitions. Implements, fencing and planting material have been supplied.

X. General.

The new "Plant Importation Rules 1928," and "Plant Notification Rules 1928," Johore came into force during the year.

Shows.—The Malayan Exhibition was held in Ipoh from August 3rd to 6th. The number and quality of agricultural exhibits were well below expectations.

The Lower Perak Agri-Horticultural Show was held in Teluk Anson on September 9th and was probably the best of its kind ever held in the district. Considerable interest was shown by small Asiatic cultivators, especially Malays.

The exhibits in the fruit and vegetable sections were large, varied, and of a commendable order.

A successful two days' show was held at Taiping on August 19th and 20th. All classes and sections were well supported. Great interest was displayed in the sections dealing with padi and poultry.

The Malacca branch of the Malayan Agri-Horticultural Association held its annual show on July 21st and 22nd. Fruit and vegetables were well represented, but other agricultural sections were not up to general expectations. In the hope of exciting more general interest, the inauguration of district shows is contemplated in the future.

Examinations of several large areas of land have been made, and reports on the suitability for the cultivation of various crops, notably padi and oil palms submitted.

Examinations for promotion from Junior to Senior Agricultural Assistant were held during the year. Four members of the division presented themselves but were not successful.

Distribution of Planting Material.—Apart from material supplied to schools, 9,449 fruit seedlings, marcots or grafts were supplied to small holders from nurseries in Pahang. Small distributions were also made from Seremban.

A. E. Coleman Doscas,
Ag. Chief Agricultural Field Officer,
F.M.S. & S.S.

Kuala Lumpur,

February, 1929.

APPENDIX A.

PLANTING MATERIALS IMPORTED FROM THE NETHERLANDS EAST INDIES DURING THE YEAR 1928.

Port of Entry.	Budwood in metres.	Seeds.	Budded Stumps.	Oil Palm Seeds.	Coffee Seeds.	Coffee Seedlings.
Singapore -	9,260	359,110	5,245	100,000	133 1/3 lbs.	1,024
Penang -	9,340	21,000	10,000	1 case	...	...
Port Swettenham -	12,455	7,000	10,108	...	10 lbs.	12
TOTAL.	31,055	387,110	25,353	100,000 & 1 case.	143 1/3 lbs.	1,036

Division of Mycology.

Annual Report for 1928.

Palm Diseases.—The situation with regard to the puzzling problem of Palm diseases in Malaya has been considerably clarified. Observations made during the year on a Dwarf Coconut Estate and a Tall Coconut Estate led to conclusions which receive more support every month. A general account of the whole of the Palm disease investigations was written up and published as a double number of the Malayan Agricultural Journal, September—October Nos. 9-10, 1928.

The common association of a new species of *Marasmius*, named *Marasmius palmivorus* Sharples, with diseases of African Oil Palms, Dwarf Coconut Palms and Tall Coconut Palms has been proved and the method by which the fungus accelerates defoliation in false "Bud-Rot" patches explained.

Since starting to write up the work further supporting evidence has been obtained which clears up the position regarding "Bud-Rot" caused by Lightning-Strike. In August last a questionnaire explaining the difficulty was sent out to thirteen Coconut Estates, and the Managers were asked to co-operate by noting when lightning storms occurred in close proximity, and the date when patches of dead and affected palms were observed. Six replies have been received and visits made to verify the information. In all these cases, patches of affected palms were found, three to seven days after the storm, some in places near to bungalows or office buildings where it would be impossible to miss noting any occurrence of the kind. Other cases have been notified which were observed visually by trustworthy observers, and I have no further hesitation in stating that Lightning is a factor of importance in the causation of palm diseases, more especially on Tall Coconut estates. The affected areas were all the same, two or three palms killed outright and the neighbouring surrounding 8-12 trees slightly affected, showing the usual broken or tipped leaves.

An important part of this work will be the discovery as to whether the larger areas of Tall Coconuts, in which 50-200 trees in a solid block are affected, can be attributed to the

same cause of Lightning. Up to date there is no direct evidence to support this view, although the symptoms shown by the affected trees in these larger blocks are similar in every respect to those in the smaller, proved Lightning Strike patches. In the last proved case, however, during one short storm three small patches were affected. There had been no further lightning storms between the date the storm took place, and the date the affected trees were found. Two patches were found at a distance of five chains apart and the third some seventy chains away from the other two in a N.W. direction. There is every reason for stating that all three patches were struck during the same storm, whether simultaneously by the same flash or otherwise, it is impossible to say. But if the three patches could be consolidated in one area, the number of trees affected would have approximated to the number of trees affected in a typical larger area. The capricious effects of Lightning are well known and it is tempting to regard Lightning as the initiating cause of the whole of the phenomena under investigation; however, until definite evidence is forthcoming, the initiating cause in the larger affected areas of Tall Coconuts must be regarded as non-proven.

The findings are of great importance to Malaya in so far that the evidence obtained justifies the statement that it is probable that no definite form of epidemic Bud-Rot, caused by a parasitic organism exists in Malaya. Perhaps, of almost equal importance is the fact that Malayan observers can now deal confidently with particular diseases, without risk of being side-tracked by phenomena which are apart from the investigation in hand.

Oil Palms.

Marasmius palmivorus Sharples was obtained from Oil-Palm estates in Selangor where it caused damage to the ripe fruit. The fungus was more common in damp humid areas than in dryer ones. Close planting and insufficient pruning increases the humidity and favours the growth of the fungus. On palms where the decaying, non-pollinated, bunches were not removed and other debris was allowed to lie around on the ground, the fungus was vigorously attacking the mature fruit bunches. The fungus was fruiting profusely and appeared to be spreading rapidly.

A Stem-Rot was examined, with which White Ants and a *Thielaviopsis* sp. was associated. This stem-rot, with which White Ant attacks are linked up, appears to be a rather serious matter, and one which requires attention in order to determine whether the losses are directly due to the insect attacks. If the insects are primarily responsible, the only preventive measures worth adopting are those of clearing timber as thoroughly as possible.

A root disease, with which a Ganoderma sp. was associater, was examined on one estate; reports of similar trouble and similar specimens were received from two other estates. The trouble was not serious, only three trees being killed.

Fomes lignosus Klotzsch, has been found growing on the old pruned leaf-bases at soil level, but no damage was done. This finding is interesting as this fungus has recently been reported to be the cause of a stem-rot of Oil Palms in Sumatra.

The root disease, with which the Ganoderma sp. (supra) was associated, in one case appeared to have originated from a large, decaying jungle root. The affected roots of the oil-palm were growing through this rotting jungle root, and the majority of the larger ones were decaying with a brown rot. The jungle root contained the same mycelium as the Oil Palm roots. The fungus had passed up the stem of the palm and the decay was evident to within a couple of feet of the crown. All the stem tissue from the base to half-way up the stem was involved, but near the limit of decay the central tissues were sound and bounded on both sides by diseased tissue. The hyphae in the tissues at the extreme margin of spread were similar to those found in the roots. Isolations from the margins yielded brown mycelium similar to that found in the tissues; the fungus grows well on Agar media and blocks of Oil Palm tissue. No fruit-bodies have developed up-to-date. Inoculations have been made with this fungus but the results are not yet to hand.

A *Thielaviopsis* sp. has been isolated from a decay of pruned leaf bases. If young leaves are pruned too early, the leaf bases remaining attached to the tree are liable to decay with a soft-rot which gives off the characteristic odour associated with attacks of *T. ethaceticus*. The pruned surface turns mauve-grey in the centre, due to the presence of this fungus, and the tissues disintegrate. The fungus appears to

die out before reaching the stem-tissues, and so far, no penetration of the stem-tissues has been observed.

Attention has recently been directed to symptoms shown by the falling out of nearly ripe fruits or by the fact that individual fruits can be easily pulled out before maturity. Preliminary investigations show a discoloration of the tissue of the fruit stalk which seems to pass into the stem tissues.

Areca Palms.—The definite association of *Polyporus ostreiformis* Berk. with certain symptoms of disease in Areca palms has been noted in previous years. An attempt definitely to prove the cause by inoculation experiments will be made when time permits.

Phytophthora species.—Twenty one species of *Phytophthora* were under study. Of these, eight were obtained locally; six being from bark and fruit diseases of *Hevea*, one from a wilt of Sireh (*Piper Betle* L.) and one from a disease of Roselle fibre (*Hibiscus sabdariffa* L. var. *altissima*).

Three species of *Phytophthora* were isolated from Black Stripe disease of *Hevea* i.e. (1) *P. palmivora* Butl. (*syn. P. faberi* Maubl.), (2) *P. meadii* McRae, (3) A new species. Two species of *Phytophthora* and one species of *Pythium* were isolated from Patch Canker of *Hevea* i.e. (1) *P. palmivora* Butl. (2) An undetermined species (3) *Pythium* sp. (*P. complectens* Braun?). This *Pythium* sp. and the new species of *Phytophthora* were also isolated from diseased pods of *Hevea*.

Inoculations with all the above mentioned species proved that they were capable of causing the diseases from which they were isolated, and, in the case of the *Phytophthora* species, that each one was capable of causing Black Stripe, Patch Canker and Pod-rot. Certain other species of *Phytophthora* including *P. palmivora* Butl. from Coconut and Cotton, (West Indies), and from Coconut (India); *P. parasitica* Dast. from Tobacco (Sumatra); and Castor Oil (India) and from Roselle fibre (Malaya), and a species from *Piper Betle* L. (India), are capable of causing Black Stripe and Patch Canker of Hevea if inoculated into the bark.

The species responsible for the wilt of *Piper Betle* L. in Pahang has been identified as *P. colocasiae* Rac.

Pythium species.—Three parasitic species have been isolated :—(1) *P. complectens* Braun? from Hevea, (2) *P. splendens* Braun from Begonias, (3) *P. aphanidermatum* (Eds.) Fitz. from Zinneas and Amaranthus plants.

Hibiscus sabdariffa L. var *altissima* (Roselle fibre).—A disease of this crop has been recorded in previous reports, but it was only in this year that the casual organism (*Phytophthora* sp.) was isolated. The disease starts as a rule at soil level, and is characterised by a blackish brown discoloration which extends up the stem often to a height of two feet. The discoloration is due to the presence of fungi and bacteria in the tissues, following the advancing mycelium of the *Phytophthora* sp. which can be found in the cortex some distance in advance of the edge of the discoloration on the stem. The disease is serious in soil which is not properly drained. Under such conditions more than 60% of the plants may be infected. The fungus is very similar to a strain of *P. parasitica* Dast. received from India and to a strain of this species from tobacco (Sumatra).

Sclerotium Rolfsii Sacc.—Strains of this fungus were studied and an article was published in the Malayan Agricultural Journal. Tomatoes were recorded as another host of this fungus in Malaya.

Rice Diseases.—There were no serious diseases of rice reported during the year. Some diseased plants were examined and found to be blackened at the base. A *Thielaviopsis* sp. was isolated, but proved to be only slightly parasitic when inoculated into young seedlings of seraup 15.

Banana Diseases.—The intensive study of Banana diseases was continued during the year. As mentioned in previous reports, this study is one of primary importance from an Imperial point of view. The disease of Bananas, known as Panama Disease, is causing great losses in the British Colonies which rely upon this commodity as their chief export.

The cause of the disease is a fungus, named *Fusarium cubense* (Erwin F. Smith). A Fusarium fungus similar to *Fusarium cubense*, was isolated from diseased banana (Pisang Embun) suckers obtained from Titi, Negri Sembilan, during the early part of January. Cultural and morphological characters of this *Fusarium*, and the type culture of *F. cubense*

(imported from Manila) agree in many respects. Comparative inoculation experiments have been carried out with these two Fusaria together with a Fusarium isolated from diseased "Pisang Restali" suckers in Johore. Of the three Fusaria, the one from Titi shews the greatest dissimilarity in culture, owing to the production of a much lighter colour and stronger odour when grown on steamed rice, and also in the production of blue-black sporodochia on steamed potato plugs.

Preliminary inoculations with the Fusarium from Johore on semi-mature Pisang Restali, made on October 14th 1927, showed positive results on January 30th 1928; the controls remained unaffected. The Fusarium was re-isolated from the diseased plants, grown on steamed rice and re-inoculated into other Pisang Restali suckers. These inoculations were carried out on semi-mature suckers and positive results were obtained three months later. Similar successful inoculation experiments have been carried out on Pisang Embun.

Detailed inoculation experiments were carried out on "Pisang Embun" and "Pisang Restali" and the native species *Musa Malaccensis* and *Musa Violescens* on February 12th, with the two Fusaria from Johore and Titi, and also the type species from Manila. Twenty five months old suckers of each of the varieties, Pisang Restali and Pisang Embun were inoculated, together with twelve suckers of *M. malaccensis* and six suckers of *M. Violescens.* These suckers are just approaching maturity and symptoms of Panama Disease are present on one Embun sucker inoculated with the Fusarium from Titi, also on two Embun suckers inoculated with the type culture of *Fusarium cubense* from Manila. None of the controls up to the present time have shown any symptom of Panama Disease.

The preliminary inoculation experiments, which were started about a year ago, in connection with Panama Disease, now show that of the fifteen varieties of bananas worked with, Pisang Embun and Pisang Restali are definitely susceptible to Panama Disease, and that the disease has been transmitted through the rhizomes of the parent to the daughter suckers.

Indications of a wilt were present on one of the inoculated suckers of Pisang Kelat and Pisang Awak Legor. From the discolored vascular tissue of the pseudostem a Fusarium species, similar to *Fusarium cubense,* was isolated from each

sucker. The internal symptoms of Panama Disease were not typical within these two varieties.

Bacterial inoculations were carried out on Solanaceous plants with a bacterium isolated from bananas; this organism was found associated with a disease on plants grown in Johore. The bacterium was isolated from the gummy exudate of a banana sucker, affected with a wilt disease which appears to be similar to a bacterial banana wilt disease recorded from Trinidad by Ashby. The bacterium isolated from the diseased banana sucker in Trinidad is similar to *B. solanacearum*, and inoculations with the bacterium from diseased banana tissue, on solanaceous plants, have given successful results in Trinidad. Two preliminary inoculations with the bacterium from Johore were successful.

Various saprophytic species of Fusaria have been isolated from the decaying leaf bases and from the out-side of the pseudostems of many varieties such as P. Embun, P. Restali, P. Susu, P. Kapas, P. Talam, P. Lilin and from P. Rajah Udang. The only Fusarium similar to *F. cubense* which has appeared growing in a saprophytic state, has been found on P. Embun and P. Restali only. According to Reinking and Wollenweber the fungus *F. cubense* appears to exist in four forms which are classified as follows :—

Forma 1—Saprophytic form producing a benzolic odour.

Forma 2—Saprophytic form without odour.

Forma 3—Parasitic form with odour (cause of banana wilt).

Forma 4—Parasitic form without odour (synonym *Fusarium cubense* var *inodoratum*, Brandes).

Nos. 2, 3 and 4 of the above appear to be present in Malaya according to isolations, and further soil isolations will possibly show that Forma 1 also exists. Final proof that the above saprophytic forms are present in this country can be obtained only by means of comparative inoculations with the parasitic forms. These inoculations will be carried out shortly.

Other fungi which have been conspicuous amongst the fifteen varieties of bananas, used in connection with Panama Disease, are a *Trichothecium* species and a *Marasmius* species. The former grows vigorously as a saprophyte on the leaf

bases of P. Talam and P. Susu and produces thick sporodochial masses, which *"en masse"* resemble the sporodochia produced by *F. cubense.* On P. Rajah Udang and P. Rajah the Marasmius species appears to be semi-parasitic. The poor growth conditions in the initial stages caused the suckers to become weakly, and an opportunity was thus afforded for the rapid spread of the fungus. The same Marasmius species *M. palmivorus* (Sharples) is the cause of a disease of Coconuts and Oil Palms (Supra).

Twenty four of the following varieties of bananas have been planted out at Jelebu in an area affected with Panama disease. P. Serendah, P. Restali, P. Kelat, P. Mas, P. Rajah P. Hijau, P. Embun, P. Rajah Udang, P. Talom, P. Laing, P. Boyan, P. Embun Buaya, P. Awak Legor, P. Awak Betol, P. Lemak Manis, P. Nangka, P. Mundan, P. Keling, P. Abu, P. Sevaly, P. Batu, P. Lilin, P. Jari Buaya, and P. Susu. Twelve suckers of each variety were used. Six suckers of each of these varieties have also been planted out on virgin land.

Six suckers of each of the above varieties have been planted out at the Government Experimental Plantation, Serdang, and inoculated by means of the "Spore Suspension" method. Three suckers of each variety were inoculated with the type culture of *Fusarium cubense* from Manila and three suckers of each variety were used as controls. The chief object of these experiments is to compare the natural method of inoculation with the artificial method, under varied conditions. Up to the present time, the suckers appear to be growing satisfactorily and have shewn no symptoms of disease.

An outbreak of Panama disease has recently occurred in Perak. A Fusarium sp. has been isolated which is similar to the one isolated from suckers affected with Panama disease at Titi, the only difference being that in culture, the Perak fungus does not produce a benzolic odour while the latter does. The Perak fungus appears to be a variety of *F. cubense* i.e. *Fusarium cubense* var. *inodoratum.* According to Brandes this variety can only be distinguished from the latter by the absence of a benzolic odour when grown on steamed rice.

A series of bacterial inoculations are being carried out, at the present time, with a bacterium often associated with *F. cubense* in culture. This is a yellow bacterium and ap-

pears to be somewhat similar to the bacterium (*Pseudomonas celebensis*) isolated by Gaumann in Java from P. Rajah bananas; these plants were affected with a vascular disease which, according to its internal and external symptoms is very similar to Panama Disease. A few preliminary bacterial inoculations have been carried out on the leaves and stems of P. Rajah but up to the present time no positive results have been forthcoming. Gaumann claims to have obtained positive results from his leaf inoculations within two weeks, but leaf inoculations carried out here over a month ago, are still negative.

Fusarium sp. on Chillies.—A disease of Chilies in which the leaves fall and the flowers wither, was examined. Some of the roots were found to be diseased, and a Fusarium sp. was isolated. Inoculations on unwounded plants were inconclusive.

Rhizoctonia sp. on Groundnuts and Potatoes.—A species of Rhizoctonia was found associated with a disease of Groundnuts and with a disease of Potatoes, the latter from Fraser's Hill.

Leaf Disease of Sisal Hemp.—A leaf disease of Sisal Hemp has been examined. As a result of this disease, fibre extraction is seriously interfered with, and only short fibres can be obtained from affected leaves. The important fungus appears to be a species of *Fusicoccum* (Corda).

Hydnocarpus Wightiana.—This plant suffers from a type of Die-back; affected plants usually show diseased roots.

Cinchona.—Cinchona plants showing root disease have been received from Cameron's Highlands. Diseased leaves of *C. ledgeriana* show an interesting Ascomycete probably a species of *Parodiella*. But for the absence of an "ostiole" to the Ascus, the fructifications closely approximate to the measurements given for *Mycosphaerella Thea* K. Hara, a fungus which causes a leaf disease of Tea.

Cladosporium fulvum.—This fungus was found causing damage to the leaves of Tomato Plants grown in Cameron's Highlands.

Tea leaves, with spottings, from Cameron's Highlands were found to be attacked by *Phyllosticta Thea* (Spechnew).

Kapur.—Kapur seedlings (*Dryobalanops aromatica*) were attacked by *Gloeosporium alborubrum.*

Bakau.—Bakau seedlings (*Rhizophora mucronata*) were attacked by a *Cytospora* sp.

Roses.—Specimens of Leaf Blotch caused by *Actinonema Rosea* (Lib.) Fr. were sent in for examination. A *Phragmidium* sp. probably, *P. subcorticum* was received from Penang. The variety effected was "Maman Cochet" and it seems impossible to grow this variety successfully in certain parts of Malaya because of the attacks of this fungus.

PUBLICATIONS.

Sharples, A.—Palm Diseases in Malaya. M. A. J. (Double Number). Vol. XVI, Nos. 9—10, 1928.

Thompson, A.—A preliminary note on Phytophthora spp. found in Malaya. M.A.J. Vol. XVI, No. 2, 1928.

Thompson, A.—Notes on *Sclerotium Rolfsii* Sacc. in Malaya. M.A.J. Vol. XVI, No. 2, 1928.

Ward, F.S.—Preliminary report on *Fusarium cubense* causing Panama Disease in Malaya. Vol. XVI, No. 3, 1928.

A. SHARPLES,

Government Mycologist,

S.S. & F.M.S.

January, 1929.

Division of Soils & Plant Physiology.

Annual Report for 1928.

Staff.

The staff of the Division at the end of the year was:—

Plant Physiologist (in charge Division)	... Mr. W. N. C. Belgrave
Assistant Chemist (Soils)	... Mr. J. H. Dennett
Junior Agricultural Asst.	... Haji Abdul Wahid
Do.	... Inche Ahmat bin Indot
Do.	... Inche Jalaludin
Do.	... Inche Mohd. Shafie b. Taib

Six Laboratory Attendants.
Two Peons.

Work.

The work of the Division continued to be on soils, and the major portion of our time was spent on the continuation of the soil survey Cheras—Klang—Coast. As the selection of this area has been criticised on the score that it covers land already thoroughly well known it may be appropriate to quote from my last Annual Report the reasons for selecting this particular area.

> "The field for soil work in Malaya is virgin to an exceptionally and embarrassing degree, not only have no systematic investigations hitherto been carried out, but as far as the rolling or hilly inland soils (the back-bone of the country) are concerned there is absolutely no information as to their cultural characteristics which could be used as a basis for research. The reason for this is that our only inland large scale crop, rubber, is remarkably tolerant of a wide range of soil conditions and that manuring of rubber has never been practised. The most urgent problem appeared to be that of systematics, viz. the establishment of soil types and the relating of these types to the underlying parent material."

"*Soil types*:—To characterise types it was decided to carry out a soil survey of a limited and accessible area. The area selected was a strip in Selangor running from Cheras, through Serdang along the Klang valley to the Coast. This area has the advantage of including all the important geological formations on the west side of the Peninsula and also of including the Government large scale experimental plantation at Serdang."

It was clearly necessary to select an accessible area for an extremely detailed survey: from this detailed survey it was hoped that deductions could be drawn which would very greatly simplify the task of surveying or predicting the properties of areas on a geological formation of known type.

At end of the year the survey had reached the low-lying areas around Klang and had been slowed down considerably by unfavourable weather conditions.

426 samples representing 111 profiles were taken, the pH estimation and mechanical analysis completed. 268 of these samples were examined for the silica/sesquioxide ratio.

Subject to confirmation by sampling a number of similar geological areas in different parts of Malaya it seems possible to say that soils formed from "quartzite" are deep and sandy with not infrequent beds of shale and sometimes thin layers of "laterite." Peaty formations are common in broad valleys. These soils readily become compacted in spite of the high percentage of sand.

The Raub series (Phyllites) produce the soil usually known as 'laterite' containing a fairly high percentage of 'clay' and much concretionery gravel, and in general a marked 'crumb' structure.

The granite produces usually a permeable soil, consisting chiefly of coarse sand and clay.

The calcareous areas have not yet been investigated; and no simple relationships have been found for alluvial soils in the area under survey.

Padi Soils.—517 more samples were received from the Field Division; all have been subjected to mechanical analysis and pH determination.

Results confirm the opinion expressed in my last report that a fairly high percentage of sand is not necessarily a bar to good production; this may be seen from the following table, which shows the number of samples falling within each class.

% Sand 0—20	21—40	41—60	61—80	Yield in Gantangs
4	4	3	1	0— 80
5	13	10	4	81—180
11	21	19	10	181—280
9	23	24	5	281—380
5	12	11	3	381—480
3	1	3	—	481—

It seems to follow this that an area otherwise suitable, especially as regards water and population, need not be rejected for padi growing merely because of a somewhat high sand content.

Analysis of 100 of these soils for phosphorus content, (total, available and in fine fractions), acidity, percentage organic matter, and ammonification when flooded have yielded no correlations. This although disappointing is perhaps not surprising in view of the very large number of factors which may cause yields to become lower than the soil is capable of producing—attacks by birds and animals, inadequate attention and most important of all, lack of water control.

These numerous interfering factors will probably make it impossible ever to obtain mathematical correlations, but should not interfere with the collection of information in a negative form such as that provided by the sand-yield table given above, it may for example be found that a low content of potash does not interfere with good yield, etc.

Talang Experimental Station.—Mechanical analysis of 86 soil samples were carried out for the Agricultural Field Officer, Perak North of soil from this Station to ascertain the degree of the variability. In addition total and available

phosphorus was determined on the manurial plots—and it is interesting to note that while total P_2O_5 showed no significant increase even on the plots which had received phosphatic manures for 10 years, the citric soluble (available) P_2O_5 gave very clear increases on these plots.

Padi Tanks—Fifty experimental tanks $6' \times 4'$ completely enclosed by wire netting and with pumping plant and reservoir were constructed at Serdang Experimental Plantation in the latter half of the year. I have to express my best thanks to Mr. T. D. Marsh, Assistant Agriculturist, who took charge of this work. In these tanks all soil and water conditions will be capable of strict control.

Manurial Experiments.—A preliminary series of pot culture experiments on the three types of inland soil mentioned above which for convenience may be called the quartzite, laterite and granite, were carried out with Ragi. There were 100 pots for each type of soil and the experiment was laid out to test the effect of added nitrogen, phosphorus, potash in artificials alone and in combination, farmyard manure (as a standard and not as a practicable proposition), green manure with small quantities of artificials—calcium and sulphur, all the above with lime, lime alone and controls. There was considerable mortality in the early stages and yield variation from pot to pot, but even after discounting these adverse factors it clearly emerges that phosphorus is essential for successful growth and that (in these cultures) added potash was not required. Nitrogen with potash gave increased yields only on the quartzite. Lime alone showed no significant difference while it was harmful in conjunction with complete artificials. Cow dung and green manure with a small amount of artificials gave excellent results, green manures alone only small increases, while the best results were obtained by lime with cowdung—which in conjunction of the failure of lime with artificials suggests a bacteriological problem. The conclusions reached will be tested in the field in 1929; but even these very preliminary experiments suggest very strongly that when attention is turned to crops other than relatively slow growing trees such as rubber, the inland soils of Malaya will not be found to possess any peculiar properties of richness exempting them from the world-wide need for manuring in some form or other.

Percolation Experiments.—A number of large pots holding about 23 kilos of soil were set up for percolation experiments, half with 'quartzite' and half with laterite soil. These were treated with lime in varying quantities, different forms of nitrogenous manures—ammonium sulphite, urea, calcium cyanamide, ammonium phosphate, potassium nitrate, and a heavy dressing of grass turned under; the percolate was analysed for nitrate nitrogen. Results shewed that nitrification was somewhat slow in both soils but otherwise according to expectation—alternate plots were then planted with grass and in every case the nitrate in the percolate from the grassed pots dropped practically to zero and remained there. This raises interesting speculations as to the wisdom of heavy grass covers for growing crops. It was further found that the acidity of the percolate was directly proportional to the quantity of nitrate present. This supports the opinion expressed in my last report that the discrepancy below the pH value of suspensions and filtrates (ratio soil: water, 1:2) is due to the absence of soluble anions to act as carriers of the hydrogen ion.

Methods of Analysis.

1. Work on the estimation of phosphorus by a modified Denigès method was completed.

2. A considerable time was devoted to the study of different methods of base exchange. None proved entirely satisfactory in view of the extremely low base content of most Malayan soils, work is proceeding.

3. The molybdate colorimetric method for silica was studied and work is being conducted on a rapid method of arriving at the sesquioxide content by precipitation with phosphate.

4. The cobaltinitrite method for potash is being studied.

5. The Bouyoucos hydrometer method of soil analysis was examined and found sufficiently accurate for much of our work.

Cover Crops.

A certain number of leguminous covers were successfully grown in sand culture without nitrogen, resulting in the

formation of numerous nodules, these were used to inoculate seed planted at Serdang and the resultant crop showed a distinct increase of inoculated over the uninoculated plots. This work will be extended.

Miscellaneous.

1. The pot experiments on the use of sulphur for amelioration of heavy soils did not give positive results.
2. The soil of certain well defined and extensive infertile patches on two adjacent coconut estates is under examination.

Routine Analysis.

292 samples were examined for officers of this and other Departments and for the Public.

General.

Work mentioned in my last report and not in this has been temporarily held up for more urgent problems.

Publications.

Soil Analyses and their limitations, by W. N. C. Belgrave. (M.A.J. August, 1928, Vol. XVI).

The Colorimetric estimation of phosphorus in acid soil extracts, by W. N. C. Belgrave. (M.A.J. November, 1928. Vol. XVI).

An improved method of fusion for soils, by J. H. Dennett. (M.A.J. November, 1928, Vol. XVI).

A comparison of the Robinson, International and Bouyoucos methods of mechanical analysis on non-organic soils and the analysis of such soil with and without preliminary treatment with hydrogen peroxide, by J. H. Dennett. (M.A.J. November, 1928, Vol. XVI).

(Sd.) W. N. C. Belgrave,
Plant Physiologist, F.M.S. & S.S.

Kuala Lumpur,
28th January, 1929.

Agricultural Instructor (Malay Officers).

Annual Report for 1928.

1. Staff.

Raja Musa bin Raja Mahadi, Junior Agricultural Assistant, was transferred to the Co-operative Societies Department on 1st March, 1928, and was succeeded on 1st May by Enche Din bin Embi.

2. Malay Apprentices.

22 Malay Apprentices were in course of training at the commencement of the year, as follows :—

	F.M.S.	S.S.	Johore.	Kedah.	Total.
1st Year Students ...	7	2	3	1	13
2nd Year Students ...	7	2	nil	nil	9
	14	4	3	1	22

The Apprenticeship of 5 Students (4 F.M.S. + 1 Johore) was terminated in April, 1928.

15 Malay Apprentices were appointed and commenced their training in May; they were recruited as follows:—

F.M.S.	S.S.	Johore.	Kedah.	Kelantan.
9	1	3	1	1

Of the newly appointed Apprentices, one developed consumption in September, and was granted extended sick leave without pay until March, 1929.

The Strength of the School at the end of the year was therefore as follows (omitting the Apprentice on leave):—

	F.M.S.	S.S.	Johore.	Kedah.	Kelantan.	Total.
1st Year Students ...	8	1	3	1	1	14
2nd Year Students ...	6	2	2	1	—	11
	14	3	5	2	1	25

3. Training.

Three terms were held during the year, as follows:—

		Working days.
3rd Term : 25th January to 14th April	...	65
1st Term : 14th May to 31st July	...	65
2nd Term : 3rd Sept. to 21st Dec.	...	92
Total	...	222

Lectures were given throughout by the Agricultural Instructor (Malay Officers) and the Assistant Agricultural Instructor.

Visits were paid to the Government Experimental Plantations, Serdang and elsewhere at intervals during the year; while the Agricultural Instructor accompanied the 2nd Year Students on a Field Tour from 12th to 21st March, inclusive, visiting estates and experiment stations of interest.

Practical gardening was included in the work of the 1st Year Students throughout the year, while 2nd Year Students underwent a course of instruction in Typewriting from May to July at the Evening Classes in Gombak Lane. One hour a week was devoted to Lectures and Debates, organised by the Students themselves.

The annual examinations were held in April. Of 9 2nd Year Students, 6 were successful, and were promoted to Junior Agricultural Assistants, being posted to divisions as follows:—

Field Division	...	3 (1 F.M.S. & 2 S.S.)
Economic Botanist	...	1
Plant Physiologist	...	1
Agricultural Instructor (M.O.)		1

Of 13 1st Year Students, 11 were promoted to the 2nd Year class. The apprenticeship of the remaining 3 2nd Year and 2 1st Year Students was terminated.

The 15 Apprentices newly appointed in May entered the 1st Year Class. These students come under the revised Scheme for Malay Officers, and therefore study for three years instead of two. The syllabus of instruction in the 1st

Year Class was therefore modified in order that the necessary groundwork be taken more thoroughly.

4. Health.

The health of the Malay Apprentices was satisfactory throughout the year, there being a conspicuous reduction in the amount of fever. One student unfortunately contracted tuberculosis, and was in hospital for some weeks; following a Medical Board in October, he was granted extended sick-leave without pay and was still absent at the end of the year.

5. Discipline.

The discipline of the students was satisfactorily maintained.

6. Promotion of Junior Agricultural Assistants.

Three examinations for Junior Agricultural Assistants to qualify for promotion to the rank of Senior Agricultural Assistant were arranged during the year; only one of five candidates satisfied the examiners. A Kedah agricultural officer was similarly examined in January, 1928.

7. School of Agriculture, Malaya.

The site selected for the School of Agriculture at Serdang was kept in clean condition, and boundary drains were improved during the year. A site for the Principal's quarters was levelled, and an access road thereto was commenced.

It was decided that the building of the School should be undertaken by the Public Works Department, which submitted new plans in December. Sums of $75,000 and $20,000 have been entered in the 1929 Estimates of the F.M.S. and S.S. Governments respectively as first votes for this enterprise.

Proposals were submitted, and were under consideration at the end of the year, for lighting and water supplies

at Serdang as joint schemes for the School and the Experimental Plantation.

The Advisory Committee for the School held a meeting on 19th December, 1928.

The offer of a Scholarship, to be called the "Edwin Philips Scholarship" was gratefully accepted.

8. Malay Officers Training Committee.

This Committee met twice during the year, on 10th February and 15th November.

9. Malay Officers Conference.

A Conference of Malay Officers was held at Headquarters from 26th to 28th January inclusive.

10. Publications.

The Agricultural Instructor (M.O.) issued the first two of a series of Instruction Manuals for Malay Officers towards the end of the year, as follows:—

(a) Introduction to Genetics

(b) Agricultural Economics.

The Assistant Agricultural Instructor assisted in the publication of the "Warta Perusahaan Tanah", to which he also contributed an article on Plant Propagation.

11. General.

The Agricultural Instructor (M.O.) served as Joint Honorary Organising Secretary of the Malayan Agri-Horticultural Association throughout the year.

The popularity of the Selangor Malayan Volunteer Infantry in this division was well maintained, the Agricultural Instructor, Junior Agricultural Assistant and 20 Malay Apprentices attending the Annual Camp at Port Dickson in August.

The Agricultural Department Football Club was converted into a Sports Club early in the year, and devoted its attentions mainly to Badminton, at which a successful tournament was held in December.

G. E. Mann,

Agricultural Instructor, (M.O.)

F.M.S. & S S.

Kuala Lumpur,

5th January, 1929.

THE

Malayan Agricultural Journal.

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Notes on Setora nitens Walk., a "Nettle Caterpillar" Pest of Coconut Palms, with Special Reference to Outbreaks in the Teluk Anson and Bagan Datoh Districts.

BY

N. C. E. MILLER.

INTRODUCTION.

Setora nitens (Lepidoptera, Heterocera, Limacodidae) was first described by Walker in 1855 (1).

The first occasion on which specimens were obtained by the Entomological Division of this Department was July, 1923. They were then despatched to the Imperial Bureau of Entomology London, and specific determination was received in September of that year. Since then only brief mention of this species has been made from time to time (2—9).

From information received from planters, it would appear that this pest has been known in the Teluk Anson and Bagan Datoh Districts (Lower Perak) since 1912, but, owing to the short duration of the outbreaks and to the slight damage caused by it, it has not been regarded in the light of a serious pest.

From March, 1928, attacks of this pest have been more frequent and more widespread, and it has extended its range in some places, from young palms to mature palms. Finally, the situation has been such as to give rise to considerable alarm on the part of some of the planters in those districts.

Of the whole area, there are approximately two thousand five hundred acres in which the pest is or has been present, in varying degrees of abundance.

The writer is greatly indebted to Mr. F. R. Mason, Agricultural Field Officer, Perak South, for much information regarding the acreage and infected areas of the estates which he visited in March 1929, with Mr. Mason, for the purpose of obtaining more details regarding the life history of this insect, and also to explain control methods to the planters concerned.

The control methods recommended were generally adopted with enthusiasm, and it is believed that the results obtained will fully justify all additional expenditure of time and money.

It must be pointed out that it would be foolish to be unduly optimistic in expecting immediate results from the control methods recommended, for when once a pest has obtained such a firm hold, as has the pest in question, reduction in its numbers, or its final elimination, (which is doubtful), is likely to be spread over a considerable period.

Ultimate success depends very largely on the co-operation of all persons concerned in the affected areas.

This pest at present seems to be confined almost entirely to the plantations north of the Teluk Anson—Bagan Datoh road. There are slight traces of infestation on palms near the roadside in the Malay Reservation south of the road, but the damage done is negligible.

The spread of the larvae from young palms, i.e. palms up to about six years of age, appears to be of comparatively recent date. It is highly probable that the spread has taken place, to some extent, from "supplies" planted in the mature areas.

Distribution and Host Plants.

So far, *S. nitens* has been recorded in this country, in addition to the Teluk Anson District, from Kuala Kurau and Sabak Bernam on coconut palms, from Serdang and the districts referred to in the present paper, on oil palms (*Elaeis*

guineensis Jacq.), and from the Kuala Selangor district on Nipa (*Nipa fruticans* Wurmb.)

In the jungle areas adjacent to coconut plantations in the Bagan Datoh district there are large numbers of nil ong palms (*Oncosperma tigillaria Hort.*), and it was suspected that they might be another alternative food plant of *S. nitens*.

A very careful search failed to yield any larvae of this species, although one larva of an allied species was found.

In Java and Sumatra, *S. nitens* has a far greater range of foodplants, for, in addition to coconut, oil and nipa palms, it has been recorded on Cacao (*Theobroma cacao* Linn.), tea (*Camellia thea* Link.), Coffee (*Coffea* spp.), Chinchona (*Chinchona Ledgeriana* Moens.), Tobacco (*Nicotiana* spp.), Banana (*Musa* spp.), Pomelo (*Citrus Decumana* Murr.), Rambutan (*Nephelium lappaceum* Linn.), (10).

The Ovum.

The ova, (Plate 1 fig. 1) which are elliptical and very strongly compressed in shape, and shining yellow when first laid, are deposited on the under surface of a pinna, and usually near its tip. The surface of the shell is very finely reticulate.

The moth sometimes deposits her ova in small irregular batches, and, when laid in this manner, they slightly overlap each other.

Owing to their shining and semi-transparent appearance they are most difficult to discover. It is thought highly probable, that the empty egg shell provides the young larva with its first meal (as is frequently the case with other lepidopterous insects) for, even on fronds on which numerous young larvae have been found, no egg remains have been detected. Should the empty shell not be consumed by the young larva, it shrivels up and in that state is almost unrecognisable.

Occasionally, after a prolonged and careful search, remains of the adhesive substance, by which ova are attached to the leaf surface, have been discovered.

An ovum measures 3 mm. x 2 mm.

The Larva.

The larvae, (Plate 1 figs. 2, 3) to which the name of "nettle caterpillars" has been given, owing to their spines causing a sharp stinging sensation, analogous to that produced by "stinging nettles," if they come into contact with one's bare flesh, are readily recognised.

In colour, they are greenish yellow, or orange, or pale bluish green, with a narrow purplish stripe spotted with blue, black and yellow along the middle of the back, and with a row of purplish elongate spots bordered with yellow along the sides. These stripes are not very distinct in larvae which have only recently emerged from the ovum.

They are provided with twelve moderately long tubercles, four being placed on the front part of the body, four cn the hind part and two on each side of the back. Along the lower margins of the sides is a row of shorter tubercles. All these protuberances are armed with spines capable of "stinging".

The spines are shaded with brownish black, in the young larva. In older larvae they are purplish brown.

The urticating power of the spines increases in direct proportion to the age of the larva. In very young larvae, it has been found by experiment, that the urticating sensation is barely perceptible. The spines of a full grown larva removed from a recently spun cocoon, however, will produce intense irritation.

On hatching, the larva measures about 2 mm. in length, and when full grown, about 35 mm.

In shape, and by their gliding mode of progression, these larvae somewhat resemble slugs. They move very slowly, taking a minute at least to cover a distance of three inches.

The undersurface of the palm pinnae is always preferred by the larvae in all stages of development. Also, they are most commonly found on the lower fronds. This preference is, no doubt, due to their dislike of direct exposure to the sun's rays, and, at the same time, in that position, they would receive ample protection from rain.

The epidermis of the pinna is that part which is first attacked. Later on, the whole pinna is devoured, leaving the midrib only. A badly attacked coconut plantation has the appearance of having been partially destroyed by fire.

On reaching maturity, the larvae often fall off the frond to the ground, and shortly afterwards seek out suitable spots for the spinning of their cocoons.

The Cocoon.

The cocoon, (Plate 1 figs. 4, 5) which is completed by the larva in a little more than half an hour, is spherical in shape and light brown in colour. The diameter varies from 8mm. to 12 mm. Its surface is smooth, rather irregular, and has a dull gloss.

Cocoons have been likened by some people to small new potatoes. They resemble more closely, however, the round galls known as "oak apples" which are found on oak trees in Europe.

Various situations are chosen by the larvae when pupating. Cocoons are constructed in cracks in the soil, among roots of cover crops, among the exposed roots of the palms and among the fibre at the base of the fronds. Frequently groups of eight to a dozen cocoons have been found in a mass among the fibre. On several occasions, the writer came across a cocoon spun up in the empty cocoon of a larva of a previous generation.

The Pupa.

The colour of the pupa, (Plate 1 fig. 6) immediately after transformation is pale yellowish white. Shortly afterwards, the wing coverings, the legs and the thorax become brown, or greyish brown, but the abdomen retains its pale yellowish white colour. Prior to the emergence of the moth, the whole pupa becomes dark greyish brown. The eyes, wings and legs are distinctly visible, the legs being free, i.e. it is possible to lift them away from the body without previously cutting the integument of the pupa.

The surface of the pupa is smooth and has a greasy appearance.

Pupae vary in size according to the sex of the moth, those of the males being the smaller. They measure 9—11 mm. to 15—17 mm. in length.

The Moth.

The moth, (Plate 1 fig. 7) is a somewhat robust insect, having a wing expanse of 30—35 mm. The forewings are brownish and somewhat glossy and they have a broad, somewhat indefinite dark brown transverse band near the apex and a narrow brown diagonal stripe. The hind wings are of a unicolorous paler brown.

Life Cycle.

The life cycle of *S. nitens* has not been completely worked out, but it is thought that it occupies a period of 6—7 weeks. Twenty five to twenty seven days is the duration of the pupal stage.

In captivity the larvae do not thrive well, and frequently, even when it has been possible to keep them alive until they have spun cocoons, many of them dry up or decompose before pupating.

Isolating them in individual cages may yield better results, for, it is probable, that the larvae are able to inflict injuries on each other by contact with each other's spines.

From observations made in the field, it would appear that there is some overlapping of broods, since larvae in all stages of development have been seen at the same time.

It is important, therefore, that frequent inspections of all areas be carried out.

The life cycle of the parasite referred to is of approximately the same number of days as that of *S. nitens*.

Mechanical Control.

Handpicking the larvae and cocoons is considered the most efficacious means of ridding a plantation of this pest, when it is confined to palms up to about six years of age.

When dealing with very young larvae, it will be found that squashing them *in situ* will be more practicable than picking them. It must, of course, be borne in mind that the hands of persons employed on this work must be adequately protected, from the poisonous spines of the larvae, by binding with strips of rag.

Larger larvae may be dislodged from the leaves with a stick or a pair of tweezers, and, when the tins, with which the collectors should be provided, are full, the contents should be destroyed by burying in the soil.

The problem of control presents greater difficulties when the attack has spread to mature palms. The employment of children armed with long sticks to knock off the larvae, has been tried, but, this method is cumbersome and liable to inflict much damage to the leaves.

As an improvement on this, it is recommended that long bamboo poles, to which a rough brush is fixed, be used to brush off larvae, which, undoubtedly, would be injured in the process, and would be unable to regain the palms from which they had fallen.

The brush part of this implement could be constructed from material at hand, such as coconut husk fibre

The systematic collection of cocoons is of immense value in reducing the numbers of the pest, and can be allotted with advantage to women and children. Where there are dense cover crops however, the task is more difficult, as suitable places under which the larvae pupate, are provided.

Collected cocoons should not be destroyed. The reason for this is set forth under the section "Biological Control".

Spraying with a lead arsenate solution, mixed in the proportions of 2 to 3 lbs. to 50 gallons of water has proved effective, but it is not favoured as a control measure. owing to cost, the length of time taken to spray a comparatively small area, and to the necessity of expert supervision.

Again, spraying can be really efficacious only when one is dealing with young palms, unless a very powerful type of sprayer be used, but then, the difficulties in negotiating

the crossing of drains with a machine of this type would be insurmountable.

Biological Control.

The larvae of *S. nitens* are attacked by several parasites, one of which, a large grey and black fly, known as *Chaetexorista javana* B.B., (Plate 1 figs. 8, 9) is not unlike a "blow fly".

Chaetexorista javana, (Diptera, Tachinidae) was first described by Brauer and Bergenstamm (Denkschr K. Akad. Wiss Wien, Lxi p. 616) in 1894 and a further description of the adult, as well as a description of the puparium was made in 1925 by Bezzi (11), from material submitted by the Entomological Division of this Department.

This fly, if encouraged, will, no doubt, prove a valuable ally in combating the pest. As a check on *S. nitens* feeding on tea in Java, it has proved itself efficient (12).

This fly deposits eggs on all stages of the larvae of *S. nitens*. The maggot on hatching bores through the skin of its host and feeds on the nutritive fluids of the body. Finally the *S. nitens* larvae succumbs, but not as a rule before spinning its cocoon.

The maggot of the fly then pupates, and, in the space of two to three weeks the adult fly emerges by pushing off the cap at one end of the cocoon, in the same manner as the moth would do.

As previously mentioned, therefore, collected cocoons should not be destroyed, but should be placed in a single layer in trays covered with wire gauze having a mesh of about 5 mm. The moths emerging from non-parasitised cocoons will be prevented from escaping from the trays owing to the smallness of the mesh of the gauze, whereas the parasitic flies will have no difficulty in doing so, and thus will be free to carry on the work of destroying other larvae. As a substitute for gauze which may be hard to obtain, with a 5 mm. mesh, sheets of tin suitably bored will be satisfactory for covering the trays.

Trays which are utilised for this purpose should be supported on trestles, the legs of which are placed in tins contain-

ing water to which is added some kerosene or disinfectant. By this means, the trays are isolated from the attacks of ants, which, while destroying moths, will also destroy freshly emerged parasites, and by so doing will defeat the object of the scheme.

It is also necessary to protect the trays from sun and rain by constructing a shelter with a corrugated iron, or palm leaf roof.

Up to the present, no parasite of the ovum has been discovered.

Insectivorous birds, or birds which are more or less omnivorous such as crows and mynahs should be encouraged (13). One species of mynah (*Acridotheres javanicus* Cab.) is reported from Java as feeding on *S. nitens* pupae (14) possibly therefore, the local species *Aethiopsar fuscus torquatus* Rob, and Kloss (15), may be reckoned as a bird to be encouraged.

In the field, rats destroy a large number of cocoons, and they have been disturbed in the act of removing cocoons from trays, of which the construction was slightly defective. Ants also will penetrate freshly constructed cocoons and destroy the occupants.

Fungoid diseases appear to be responsible for the destruction of large numbers of larvae, but more information regarding them is required before they can be utilised as methods of control.

An examination of two thousand cocoons (about a tenth of the number collected on one estate) gave the following figures:—

Cocoons from which moths had emerged.	Cocoons containing dead larvae.	Cocoons containing dead pupae.	Parasitized.
1114.	543.	141.	202.

A smaller number of cocoons collected on another estate gave the same percentage of parasitization.

The larvae found dead were invariably covered with fungoid growths, the pupae only occasionally so, and the cocoon itself was usually damaged, having apparently been eaten through by ants before it had hardened.

Parasitization, as will be seen from the figures given above, is responsible at present for a comparatively small percentage of deaths, but, the writer is confident that a far greater percentage will be obtained, if the scheme of parasite breeding and liberation is carried on without intermission. In Java, parasitization in one instance reached the high figure of 88% (10).

SUMMARY.

Notes on and descriptions of the early stages and of the adult of *S. nitens* Walk. and of a parasite *Chaetexorista javana* B.B. are given.

This "nettle caterpillar" pest of coconut palms has increased in numbers in recent years in the Bagan Datoh district.

It has also extended its range in some places from young palms to mature palms.

This spread is thought to take place partly from "supplies" planted in mature areas.

The Coconut plantations in the Malay Reservation on the South side of the Teluk Anson—Bagan Datoh road are only very slightly attacked.

Systematic collection of larvae and cocoons, and the breeding and liberation of parasites are considered the most efficacious methods of control.

CONCLUSION.

The writer wishes to express his thanks to all Managers and Assistant Managers of the Estates on which these observations were made, for their help and hospitality.

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Received for publication 5th May, 1929.

Explanation of Plate.

Figure 1. Ova on pinna of Coconut.

,, 2. Larva a few days old.

,, 3. Full grown larva.

,, 4. Cocoon.

,, 5. Cocoon from which moth has emerged.

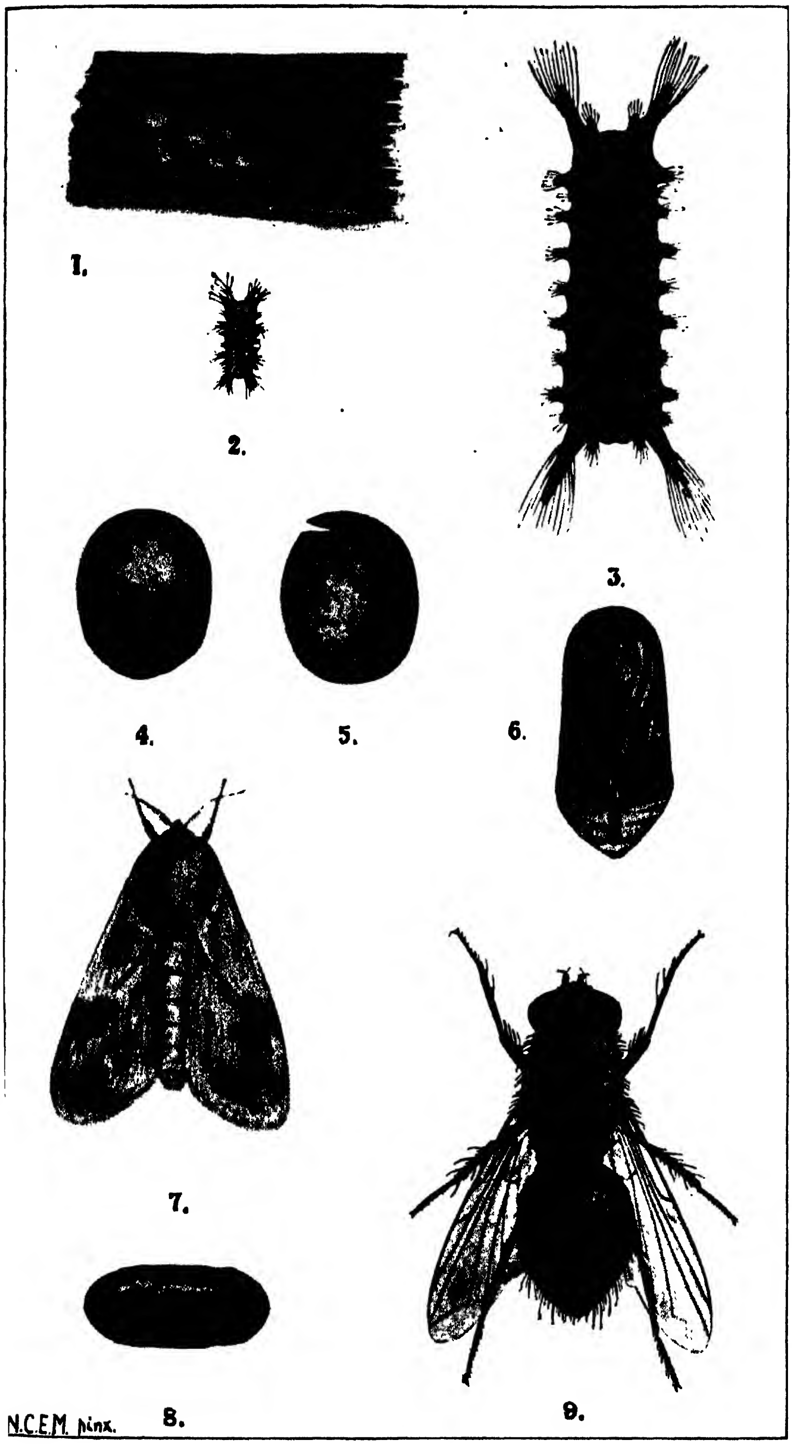
,, 6. Pupa.

,, 7. *Setora nitens*, Walk. Female.

,, 8. Puparium of *Chaetexorista javana* B. and B.

,, 9. *Chaetexorista javana*. B. and B.

(All figures enlarged.)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N.C.E.M. pinx.

The Periodic Harvesting of Tuba Root.
(*Derris elliptica*, Benth.)

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and

E. A. Curtler,
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Introductory.

The growing use of tuba, *Derris* spp., as an insecticide has resulted in an increased interest being taken in the cultivation of this crop in Malaya.

The exports from the Federated Malay States during the past three years are as follows:—

Year.	Amount. (lbs.)	Value. $
1926	54,548	24,175
1927	79,065	39,942
1928	80,263	27,357

Tuba is also being cultivated to a considerable extent in Johore, the estimated planted area for the year 1928 being 2,000 acres.

Two species of *Derris* are commonly cultivated, namely *D. elliptica*, Benth., frequently referred to locally as "tuba puteh," and *D. malaccensis*, Prain, known as "tuba merah."

Although the differences between these two species are not very marked the following are distinctive vegetative characters. The undersides of the leaflets and petioles of *D. elliptica* are softly hairy, whereas those of *D. malaccensis* are glabrous. Further, the undersides of the former are usually greyish in colour while those of the latter are light green. The young foliage of *D. malaccensis* is bright red-brown. These colour characters are probably the origin of the Malay names of the two plants.

Since it is well-known that the toxicity of tuba root, measured by the amount of ether extract, varies according to the age of the roots an investigation on both species is being carried out jointly by the Agicultural and Chemical Divisions in order to ascertain firstly the extent of these variations and secondly the optimum age at which the roots should be harvested.

The present paper deals only with *Derris elliptica*, the plots of *D. malaccensis* not yet being ready for harvesting. It is hoped, however, to publish at an early date the results of some other experiments carried out on much smaller plots on the variations in the amount of ether extract from roots of the latter species.

Field Experiment.

Since tuba is interplanted frequently with some permanent form of cultivation it was decided for comparative purposes to carry out the experiment by planting the crop with kapok *(Ceiba pentandra)*. The total area of the block chosen was 5 acres, the soil being for the most part a dark coloured clay-loam. Only 4 acres were employed for the experiment, the remaining acre consisting of an outcrop of lateritic soil on which the kapok and tuba had failed to make good growth.

Planting.

The tuba cuttings were interplanted between the kapok trees, which were spaced 20 feet by 20 feet square planting. The kapok trees had been six months in the field when the tuba cuttings were planted during September 1926. The tuba cuttings were planted in rows 3 feet apart and spaced 3 feet apart in the rows. Five rows of tuba were planted between each row of kapok, running east and west, allowing 4 feet between the outside rows of the tuba plants and the kapok trees.

This planting arrangement gave 3,555 plants per acre compared with 4,840 if the tuba had been planted as a sole crop.

The tuba stems were cut into lengths of from 15 to 20 inches and placed in the soil in a slanting direction with

about two-thirds of the length of the stem below the surface. A percentage of the cuttings failed to take root and were supplied during favourable weather.

Further experience at the Government Plantation, Serdang, demonstrates the fact that considerably better results are obtained by rooting the cuttings in nursery beds under light shade before planting in the field. By this method not only is a larger number of rooted plants ensured, thus obviating the necessity of supplying vacancies, but the risk of failure from drought is reduced as the cuttings commence to grow within a few days of being transferred.

The block was kept clean weeded during the time of the experiment, no manure or lime being applied.

Several of the plants flowered during February/March, 1928, but as usual with *D. elliptica* none of the flowers set fruit.

HARVESTING.

When the tuba root was nearing maturity, during June 1928, arrangements were made to harvest an acre at 21, 23, 25, and 27 months' growth respectively. The method of calculating this area was to take 108 squares of tuba, enclosed by four kapok trees, as an acre. Further, the method of harvesting was to divide the area into six groups of four rows, one row from each group being harvested at the conclusion of each period of growth. Since the number of kapok trees planted along the total length of six rows was 108 each set comprised one acre. Errors from variation of soil were to a great extent eliminated by means of guard rows at either end of the block and the six repetitions in each group harvested.

The first process of harvesting was to cut all stems and runners as close to the ground as possible and remove them to one side of the plot. The entire roots were then lifted, cleaned of soil and tied into bundles, which were transported to the store and weighed. The weights of each harvest are shown in Table I under the heading of "Weight of fresh roots".

During the day the roots were placed in the sun to dry and sorted into "coarse" and "fine" roots at convenient times during the process of drying.

The division of the crop into "coarse" and "fine" roots was somewhat arbitrary, the "coarse" roots being those

thicker than an ordinary sized pencil, while the remainder were considered as "fine". The reason for this division into two classes is that the "fine" roots are more acceptable on the London market, probably on account of the increased percentage of ether extract per unit weight of root. It appears that "coarse" roots are only acceptable when the "fine" roots are not offering.

Drying was continued until the roots ceased to lose weight, the details of the various harvests being also recorded in Table I. At this stage, representative samples, each weighing 25 lbs., were taken from both "coarse" and "fine" roots for analysis.

Method of Analysis.

The air-dry roots were cut into small pieces from $\frac{1}{4}$—$\frac{1}{2}$ inch long, the mass being quartered until about 3 lbs. remained. This sample was ground in a laboratory mill until it was reduced to a coarse powder, which was quartered again until approximately $\frac{3}{4}$—1 lb. remained. This quantity was ground and sieved until the whole of the material passed through a 0.5 mms. sieve. Weighed quantities of the fine powder were taken for the determination of both moisture and ether extract.

Since it is well-known that tuba root undergoes decomposition if heated for any period the moisture determination was made by drying the material over phosphorous pentoxide in vacuo to constant weight.

The amount of ether extract was determined by treating the powder with ether in a Soxhlet extractor at a temperature just sufficient to allow the ether to boil. When extraction was complete the solvent was distilled off and the residue dried to constant weight at 100°C. Although slight decomposition takes place by drying the ether extract in this manner and the results are therefore slightly low they will be comparable, since the same method was used throughout the investigation.

The results of analysis for both "coarse" and "fine" roots are recorded in Table II. In all cases the figures represent the average of duplicate determinations.

TABLE I.

Yields of Tuba Root *(Derris elliptica)* at Varying Ages.

Time of harvesting.	Age of roots. months.	Actual yield of root per acre as inter-crop.				Calculated yield of root per acre as sole crop.			
		Fresh root. lbs.	Air-dry root.			Fresh root. lbs.	Air-dry root.		
			Fine lbs.	Coarse lbs.	Total lbs.		Fine lbs.	Coarse lbs.	Total lbs.
June 1928 -	21	939	265	235	500	1277	361	320	681
August 1928 -	23	1610	452	225	677	2190	615	306	921
October 1928 -	25	1983	652	179	831	2697	888	244	1132
December 1928 -	27	2533	815	350	1165	3445	1110	476	1586

TABLE II.

Moisture Content and Ether Extract Content of Fine and Coarse Roots of Tuba Root *(Derris elliptica)* of Varying Ages.

Time of harvesting.	Age of roots. months.	Weight of air-dry roots. lbs.	Moisture content. per cent.	Calculated weight of roots on moisture-free basis. lbs.	Ether extract of roots (on moisture-free basis) per cent.	Calculated amount of ether extract. lbs.
A. Fine Roots.						
June 1928	21	265	9.49	240	7.88	18.9
August 1928	23	452	10.74	403	9.63	38.8
October 1928	25	652	11.58	576	8.59	49.5
December 1928	27	815	7.90	751	5.17	38.8
B. Coarse Roots.						
June 1928	21	235	10.29	211	6.99	14.7
August 1928	23	225	10.85	201	4.52	9.1
October 1928	25	179	16.54	149	3.18	4.7
December 1928	27	350	9.55	317	4.84	15.3

Remarks and Conclusions.

The figures in Table I indicate a gradual increase in yield in proportion to the age of the root, also that the yield of air-dry root is approximately 45 per cent. of the weight of fresh root. The moisture content of the air-dry roots is approximately 10 per cent.

The results in Table II show that for the "fine" roots the maximum figure for the amount of ether extract is obtained with roots 23 months old, the figures showing definite decreases for roots of greater age. In this connection it may be mentioned that the maximum figure for the amount of ether extract is less than that found for other samples of roots of *D. elliptica* previously examined.

The increase in the amount of ether extract for the "coarse" roots 27 months old compared with those for 25 months is probably due to a general increase in the size of the roots, resulting in a greater proportion of roots which might be classed as either "coarse" or "fine".

A further table, Table III, has been compiled from the results given in the two previous tables in order to ascertain the proportion of the weight of "fine" roots to total roots at varying ages, also the proportion which the calculated amount of ether extract for the "fine" roots bears to the total amount for the harvest.

These points are of importance from an economic standpoint, especially in view of the relatively slight decreases in the amounts of ether extract. For example, although the results in Table II show that the amount of ether extract for the "fine" roots is at its maximum after 23 months the figures in Table III show that from the point of view of agricultural practice it would be more profitable to delay harvesting until the roots are 25 months old, when both the proportions of "fine" roots to total roots and of ether extract present in "fine" roots to that in total roots are at their maxima.

Further, although the results show a definite increase in the yield of root by delaying the harvest until 27 months there is no corresponding increase in the total amount of ether extract.

TABLE III.

Proportions of Fine Roots and of Ether Extract from Fine Roots of Tuba Root *(Derris elliptica)* of Varying Ages.

Time of harvesting	Age of roots.	Total weight of roots on moisture-free basis.	Weight of fine roots on moisture-free basis.	Proportion of fine roots on moisture-free basis.	Total weight of ether extract.	Weight of ether extract from fine roots.	Proportion of ether extract in fine roots.
	months.	lbs.	lbs.	per cent.	lbs.	lbs.	per cent.
June 1928 -	21	451	240	53	33.6	18.9	56
August 1928 -	23	604	403	67	47.9	38.8	81
October 1928 -	25	725	576	79	54.2	49.5	91
December 1928 -	27	1068	751	70	54.1	38.8	72

The yield of air-dry root obtained from one acre at 25 months is found to be 831 lbs. when the tuba is planted as an inter-crop, which corresponds to 1132 lbs. per acre when planted as a sole crop. This latter figure is considered a fair average yield.

SUMMARY.

1. The present paper deals with an investigation regarding the variations in the amounts of ether extract of tuba root, *Derris elliptica*, Benth., of varying ages.

2. The results show that taking both the yield of root and the amount of ether extract into account the optimum age for harvesting is when the plants are 25 months old.

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The Oil Content of Malayan Estate Copra.

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Introductory.

Reference was made in a previous number of this Journal, Vol. XVII, 1929, No. 5, page 127 to an investigation regarding the present oil content of Malayan estate copra.

This investigation was undertaken owing to reports received from London that the oil content of Straits copra was tending to diminish. Figures were quoted to the effect that while Straits copra formerly contained 66/67 per cent. of oil and yielded 63/64 per cent. of oil recent consignments had been found to contain 63/64 per cent. yielding only 60/61 per cent. of oil on treatment. Such a statement pointed therefore to the necessity of carrying out a series of analyses to ascertain the present average oil content of the product.

Although a large proportion of the copra exported from Malaya is produced by small cultivators it was considered advisable in the first instance to limit the investigation to the estate product on account of its greater uniformity.

Methods of Analysis.

Arrangements were made with six estates distributed along the West Coast to forward at monthly intervals for a period of six months samples of their copra as exported. These samples consisted of pieces of copra drawn from the individual sacks before stitching, each sample weighing approximately 5 lbs.

The selection of average portions of copra for analysis must be carried out carefully owing to the difference in the oil content of the white meat and the brown testa, which renders it essential to take proportionate amounts of the two constituents. In the present investigation the sampling was carried out by trimming the individual pieces of copra until approximately rectangular portions of each piece remained, when a thin slice of the material was cut transversely from one side of each piece with a sharp knife. This method, although laborious, has given good results, since it is only

occasionally that the difference in oil content of duplicate determinations exceeds 0.5 per cent.

The moisture content was determined by drying a weighed amount of the thin slices for a period of 6 hours at a temperature of 100°C. The heating was not continued since in most cases it found that after this period the material had turned brown on the edges, indicating that slight decomposition was taking place. Although therefore the figures may not represent the true moisture content of the material the results are comparable.

The dried material was treated in a Soxhlet extractor with petroleum ether. The semi-extracted copra was ground in a mortar with a small quantity of ignited sand, the mixture being replaced in the extractor for further treatment to complete the removal of the oil. The petroleum ether extract was filtered, the solvent distilled off and the oil dried to constant weight.

MOISTURE CONTENT OF COPRA.

The following table gives a summary of the results of all the separate determinations for the samples examined from each estate. In order to make the table as concise as possible only the minimum, maximum and average figures have been given.

Estate reference letter.	No. of determinations.	Moisture content (loss at 100°C)		
		Minimum per cent.	Maximum per cent.	Average per cent.
A	12	4.79	6.45	5.68
B	9	4.88	6.59	5.77
C	13	4.68	8.75	7.24
D	10	6.13	8.43	7.52
E	11	6.52	9.08	7.56
F	7	6.89	8.44	7.60
Total	62	4.68	9.08	6.90

If the figures for all the separate determinations are divided into 1 per cent. groups, the first group having for its lower limit the whole number next below the minimum figure, 4.68 per cent. the various results can be grouped as follows :—

Group. per cent.	No. of determinations.
4- 5	7
5- 6	6
6- 7	19
7- 8	19
8- 9	10
9-10	1
Total	62

The results of analysis show therefore that the average moisture content of copra as despatched from estates is approximately 7 per cent. Further, the group table confirms this figure, since more than 60 per cent. of the determinations fall within the limits 6-8 per cent, approximately 30 per cent. of the determinations being within the group 6-7 per cent. and an equal number in the group 7-8 per cent.

Oil Content of Copra.

The following table gives a summary of the results of the oil determinations for the samples examined from each estate. In order to make the table as concise as possible only the minimum, maximum and average figures, calculated on a moisture-free basis, have been entered.

Estate reference letter.	No. of determinations.	Oil content (calculated on moisture-free basis)		
		Minimum per cent.	Maximum per cent.	Average per cent.
A	12	63.62	67.15	65.37
B	9	65.24	67.16	66.47
C	13	63.90	67.27	65.29
D	10	62.29	66.68	65.45
E	11	63.83	66.83	65.46
F	7	63.45	66.97	65.64
Total	62	62.29	67.27	65.61

If the figures for all the separate analyses are divided similarly into 1 per cent groups the results will be as follows:—

Group per cent.	No. of determinations.
62-63	1
63-64	5
64-65	14
65-66	14
66-67	25
67-68	3
Total	62

The results of analysis show that the average oil content of the samples examined, calculated on a moisture-free basis, lies between 65.5 and 66.0 per cent. This average figure is confirmed by the group results which indicate more than 63 per cent of the results of analysis to fall within the group 65-67 per cent, 22 per cent within the group 65-66 per cent and 41 per cent within the next higher group.

Relation Between Moisture and Oil Contents.

Although the figures for oil content have been calculated on a moisture-free basis, this being the most satisfactory method from a comparative point of view, such a basis is not practicable since copra as sold always has a certain moisture content. Further, it will be realised that, other things being equal, from the point of view of oil recovery the lower the moisture content the greater will be the oil content, that is to say, the oil content varies inversely with the moisture content.

The following table illustrates this point. Assuming that the oil content of the copra, calculated on a moisture-free basis, is 66 per cent the calculated percentages of oil in copra

in which the moisture increases from nil to 10 per cent. will be as follows:—

Moisture content per cent.	Oil content per cent.
Nil	66.0
1.0	65.3
2.0	64.7
3.0	64.0
4.0	63.4
5.0	62.7
6.0	62.0
7.0	61.4
8.0	60.7
9.0	60.1
10.0	59.4

The results show that with an increase of one per cent in the moisture content of the copra there is a corresponding decrease of from 0.6-0.7 per cent in the oil content.

Remarks and Conclusions.

The results of the investigation show that the average moisture content of estate copra is approximately 7 per cent. During the period of transit there will be a loss in weight due to further drying dependent for example on the conditions of stowage, time of transit and decrease in the humidity of the atmosphere. Further, the amount of decrease in weight will vary with the moisture content of the copra when despatched.

As far as can be ascertained the average moisture content of copra on arrival in Europe varies from 3 to 4 per cent so that, if the moisture content of the copra as shipped is 7 per cent, the loss in weight during transit will vary from 2 to 3 per cent.

As regards the oil content the results show that apart from seasonal variations the average figure, calculated on a moisture-free basis, is approximately 66 per cent.

It is difficult to suggest a reason for the alleged diminution in oil content, which is probably due to a variety of causes. For example, it is well-known that the oil content

of the brown testa is considerably less than that of the white meat and it is possible that as a result of cultivation under local conditions the thickness of the testa may have increased with a consequent diminution in the oil content of the product. It is intended at an early date to commence a series of experiments to obtain information regarding the proportions of these two constituents.

Summary.

1. The paper deals with an investigation regarding the present oil content of Malayan estate copra.

2. The results show that apart from seasonal variations the average oil content, calculated on a moisture-free basis, lies between 65.5 and 66.0 per cent.

In conclusion the writer wishes to thank both the Managers of the various estates for their kindness in supplying the necessary samples and Mr. Gunn Lay Teik for carrying out the analytical work in connection with the investigation.

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The Cobaltinitrite method for the Estimation of Potash with particular reference to soils.

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In recent years much attention has been called to the estimation of potash by the cobaltinitrite reaction first discovered by W. Fischer in 1848.[1]

NOTES ON PREVIOUS INVESTIGATIONS.

Gilbert[2] in 1898 seems to have been the first to use this method for the estimation of potassium, though he used it solely as a means of separation of the potassium from other metals, subsequently dissolving in hydrochloric acid and reprecipitating as chloroplatinate or perchlorate.

In 1900 Addie and Wood[3] proposed both a gravimetric and volumetric method for the estimation of potash by filtering the cobaltinitrite precipitate through a gooch crucible and weighing as sodium potassium cobaltinitrite or subsequently breaking up the complex with sodium hydroxide and estimating the sodium nitrite formed with potassium permanganate. At the same time they proposed a method for the estimation of potash in soils, by first precipitating the iron and alumina in the soil extract with sodium carbonate filtering off the precipitate, acidifying with acetic acid and subsequent precipitation of the potassium as cobaltinitrite.

This method does not seem to have been taken up generally possibly owing to the fact that the authors indicated the difficulty of washing the precipitate.

In 1909 Mary Cunningham and A. M. Perkin[4] in the course of work on organic cobaltinitrites remarked that the sodium potassium cobaltinitrite precipitation could not be recommended for the estimation of potash owing to the extreme difficulty of washing. "It can easily be washed once by decantation, on filling the vessel with water the precipitate settles very slowly and on the third washing shows a strong tendency to become colloidal. Finally it becomes almost impossible to filter satisfactorily."

Hamberger [5] in 1915 proposed to estimate potassium by measuring the volume of the cobaltinitrite precipitate in a special type of centrifuge tube. A modification of this method has been used by Walker and Glich for the estimation of potash in sugar cane juices.

More recently in 1928 M.M. Leulier, Velluz and Griffon [6] published a summary of previous work, together with researches of their own for the estimation of potash (between 0.1 mg. and 5 mg.) from the biological side. They again proposed the use of the centrifuge for the separation of the cobaltinitrite precipitate, subsequently drying off their precipitate with ether after washing with an alcohol, ether and acetic acid mixture. Finally they added sodium phosphate and estimated the nitrous groups with permanganate and iodine in the cold, thus elminating losses of permanganate by heating.

Present Investigations.

An examination of the cobaltinitrite method for the estimation of potash was carried out in this department primarily with a view to its application to the estimation of potash in soils, it being recognised that estimation with perchlorate led to very widely varying results, while for routine work estimation as chloroplatinate is far too expensive. For these reasons the Dutch authorities in Java have done little with potash estimations.

What seemed to be required therefore was a rapid method for the estimation of potash which at the same time should shew a good degree of accuracy.

Cobaltinitrite Reagent.

In the work to be described below the sodium cobaltinitrite reagent used was made up according to the formula of Walker and Glich[7] and was found to give very satisfactory results.

(a) *Cobalt Acetate Stock Solution.*—125 grams of the pure salt ($Co(CH_3COO)_2 3H_2O$) dissolved in 400 cc. distilled water.

(b) *Sodium Nitrite Solution.*—225 grams of the pure salt dissolved in 400 ccs. distilled water. Portions made up when required.

(*c*) *Sodium Cobaltinitrite Solution for use.*—100 cc. each of (a) and (b) made up to 430 ccs. with distilled water. 12.5 ccs. glacial acetic acid is added and the whole, with occasional stirring, left to stand for 24 hours. It is then filtered and kept in a dark stoppered bottle. It has been found that the reagent keeps fairly well if unexposed to light, but not more than a week's supply should be made at a time.

THE PRECIPITATE.

As far as can be ascertained previous workers do not seem to have reported the fact that there two distinct types of sodium potassium cobaltinitrite precipitate of similar composition which can be obtained by different methods of precipitation, though Addie and Wood[3] in their paper mention that potash should be present in a concentration of 0.5 to 1 per cent. in order to obtain a precipitate which settles readily.

It was found that using a decinormal solution of KCl (K_2O = 0.47%) a bright orange yellow precipitate is formed which settles very rapidly. With rather weaker solutions a bright orange precipitate is also formed, precipitation does not occur immediately as with decinormal solutions, but only on standing for some minutes. With still weaker solutions the precipitate is yellow.

With normal solutions of KCl an immediate precipitate is obtained, but in this case it is canary yellow in colour, similar to that obtained with the most dilute solutions. The colour of the precipitate does not depend necessarily on the concentration of the potash but in some cases on the concentration of other salts as well. If solid sodium chloride is placed at the bottom of a tube containing a decinormal solution of potassium chloride (which normally gives an orange precipitate) a canary yellow precipitate is also obtained.

From microscopic examination it would appear that the differences of the precipitates obtained under differing conditions are due to differences in the size of the crystals obtained rather than differences of form. From very dilute solutions of potash the crystals obtained appear to be of a fairly constant size (about 0.004 mms. in diameter) and cubic in form. With decinormal solutions crystals of much the same size and ap-

pearance as those obtained with solutions of the centinormal order seem to be formed first. On standing a minute however they appear to coalesce to form very well defined crystals cubic in shape and about .016 mm. in diameter.

In the case of normal solutions, solutions where the general salt concentration is very great, or in extremely dilute solutions where the canary yellow colour is obtained, the precipitate appears to be colloidal except under very high power, when again the same cubic form can be seen. In this case however the size seems to vary considerably and lies between 0.0015 mm. and 0.0007 mm.

All three precipitates seem stable in form except for the preliminary coalescing with decinormal solutions and after standing for twenty four hours they do not shew any tendancy to change.

It was thought at first that differences in appearance, even in the presence of excess of the reagent might be due to differences in composition, but subsequent examination of the cobalt content disproved this.

Not only is there a considerable difference in the appearance of the precipitates but there is a very considerable difference in the volume of the precipitate obtained (though not in weight) which seems to detract from the accuracy of centrifugal methods based on the estimation of the volume of precipitate obtained unless special precautions are taken that the concentration of other salts in the standard potash solution shall be the same as in the solution under examination. It has been found that the relative volumes of precipitate using decinormal and normal solutions of potassium chloride are between 1 to 3 and 1 to 4.

The precipitates shew very great differences in their rate of centrifuging, the orange precipitate obtained from decinormal solutions settles in about a minute at speeds of about 800 revolutions per minute even after several washings. The yellow precipitate settles fairly rapidly at first (as was pointed out by Mary Cunningham and Mollwo Perkin) but after washing there is an increasing tendancy to remain in suspension and as much as fifteen minutes are required to settle it. As would be expected with precipitates obtained from very dilute solutions, where the crystal size lies between that ob-

tained from decinormal and normal solutions the centrifuging time lies mid way between the two.

From work carried out in this laboratory it appeared that centrifuging was certainly the surest and most convenient method for the separation of the potash precipitate from the mother liquors.

The centrifuge tubes in use were made of ordinary pyrex test tubes* drawn out at the bottom to pear shape. This shape was found to help separation considerably, forming a pocket into which the precipitate could sink and this allowed the supernatant liquor to be poured off completely.

The potash solution to be examined is poured into the tube first and the cobaltinitrite reagent added in considerable excess. The tubes are then allowed to stand for twenty minutes as it was found that although the precipitation is immediate for amounts of potash of the order of 2 milligrams and over with considerably smaller amounts the precipitate only comes down on standing. The tubes are then lightly corked and centrifuged until separation is complete and the precipitate well bedded down into the pear shaped depression. The mother liquor is completely decanted, replaced with water, the tubes thoroughly shaken up and recentrifuged. The washing is repeated a second time, the wash water again decanted after centrifuging and the precipitate examined by the methods given below.

It has been found that by centrifuging in this manner, getting the precipitate well bedded down each time of centrifuging that a very complete separation is obtained, no subsequent washing, drying or filtration being necessary Eight separations can be made at once and the whole operation completed in 15 minutes.

In applying the cobaltinitrite methods to soils in Malaya where large numbers of soils have to be operated on by semi skilled assistants it appeared essential that the final estimation of the potash should be made as simple as possible. It was

* As no centrifuge capable of taking test tubes was available in the laboratory and none such could be found in any of the scientific catalogues, one was built up of "Meccano" parts (obtainable from Meccano Ltd., Binns Road, Liverpool) and driven from a small electric motor by a belt. The cups to carry the tubes were made of galvanised sheet and were coupled to the centrifuge by Meccano chain. The apparatus had been found very satisfactory and of great general utility for the rapid settling of precipitates in test tubes.

decided therefore to try whether the complex precipitate could be broken up by decinormal sulphuric acid and the excess of acid which had not combined with the metallic radicles titrated back to neutrality with decinormal soda used Brom-Thymol-Blue as indicator.

From the results of over sixty estimations by this method it was found that 1 cc. N/10 KCl was equivalent to 1.66 ccs. N/10 H_2SO_4 which would appear to indicate that a precipitate $K_3Co(NO_2)_6$ had been obtained. Subsequent estimations of the cobalt and the presence of sodium shewed however that the normal precipitate $K_2NaCo(NO_2)_6$ had been obtained. The difference therefore between a value of 1 cc. N/10 KCl = 1.66 CC N/10 H_2SO_4, and a value of 1 cc. N/10 KCl = 2.5 cc. N/10 H_2SO_4 which should be obtained with $K_2NaCo(NO_2)_6$ must be due to the presence of an acid set free during the reaction.

Examination shewed the presence of nitric acid in the sulphuric acid solution in the equivalent amount.

The reaction was also carried out in an atmosphere of CO_2 and the gas evolved was collected over caustic soda. This was found to consist chiefly of nitric oxide. Collection over paraffin shewed the fact that either a certain amount of nitrogen peroxide is also evolved, or that a small amount of oxygen is evolved and immediately combines with some of the nitric oxide.

The method compares well with the permanganate one for amounts of potash up to 23 milligrams but for potash present in larger amounts it is better to take an aliquot for its estimation by either method.

As 1 cc. of N/10 K_2O is equivalent to 1.66 cc. N/10 H_2SO_4 or to 5.5 cc. N/10 $KMnO_4$ it is of course obvious that the latter reagent gives a greater degree of delicacy and should be used when the amount of potash present is of the order of 1 mg.

Application to Soils.

In applying the method to the estimation of potash in soil it was found that the proposal of Addie and Wood worked well even when, as happens in Malayan soils the HCl extract may contain as much as 20% of iron and alumina and as little as 0.01 per cent. of potash.

The method they suggested consists in the precipitation of iron and alumina with sodium carbonate (a salt which is generally free from potash) with subsequent boiling and filtration of the precipitated carbonates, acidification with acetic acid and evaporation to a bulk of about 10 cc. (or such bulk as gives a K_2O concentration of about 0.5 to 1%).

This has been modified to some extent in this laboratory. An aliquot of the hydrochloric acid extract equivalent to 10 gms. of soil is neutralised as accurately as possible with sodium carbonate using an external indicator (the thickening of the precipitate near the neutral point with the large bulk of iron and aluminium carbonates obtained with local soils, is in itself sufficient indication.) The solution and precipitate is then made to some convenient volume and the whole centrifuged until separation of the iron and aluminium is complete. This centrifuging where the amount of precipitate is large saves a very considerable time in filtering and does not interfere with the accuracy of the estimation. After centrifuging, the whole or an aliquot of the clear liquor (the volume of which is measured) is evaporated as near to dryness as possible in a glass basin on the water bath, acidified with acetic acid and then treated with cobaltinitrite reagent in the ordinary way. It should be noted that with soils high in iron and alumina, the centrifuged liquor from which, will be high in sodium chloride may give the yellow precipitate instead of the larger crystalled orange one, and in consequence take longer to centrifuge.

As iron and alumina carbonate are soluble to some extent a small precipitation of these substances occurs when the centrifugal liquor is evaporated to small bulk. These however redissolve on addition of the acetic acid.

Addie and Wood recommend the addition of acetic acid before evaporation; there is a subsequent precipitation of basic acetates which interfere to some extent with the potash precipitation. This is avoided by addition of acetic acid subsequently, the iron and alumina then being held on solution as the normal acetates.

In order to ascertain whether potash was occluded in the iron and aluminium precipitates a number of artificial soil solutions were made up containing over 20% of iron and aluminium chlorides and known amounts of potash added. The results obtained are given in the table.

With the idea of applying it to soils to a solution containing varying amounts of citric acid varying amounts of a N/10 solution of potassium chloride were added. The citric acid was then neutralised with sodium carbonate and the solutions evaporated to small bulk. Cobaltinitrite reagent was added and the potash precipitate centrifuged out in the ordinary way. The figures obtained are given in the attached table.

Summary.

The different precipitates obtained under different conditions by the addition of sodium cobaltinitrite solution to a solution of a potassium salt are described.

2. The use of a centrifugal method of separation of the potassium sodium cobaltinitrite precipitate recommended by other writers is strongly advocated.

3. The absence of any necessity for further treatment of the cobaltinitrite precipitate after centrifuging previous to its estimation is indicated.

4. For rapid work where the highest degree of accuracy is not required and the amount of potash lies between 2 and 33 milligrams the solution of the precipitate in sulphuric acid and subsequent titration with soda using brom-thymol-blue is suggested. With smaller amounts of potash or where a high degree of accuracy is required, the solution of the precipitate in acid potassium permanganate, subsequent addition of excess of N/10 oxalic acid and back titration with potassium permanganate is preferable.

5. A modified application of the cobaltinitrite method to potash in soils recommended by Addie and Wood is described.

6. The use of a larger centrifuge for the rapid separation of the iron and aluminium precipitate is advocated.

7. It is shewn that the potash contained in a citric acid solution can be estimated by this method and it is suggested that this might be applied to the estimation of "available potash" in soils.

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TABLE.

Solution of $K_2NaCo(NO_2)_6$ in decinormal H_2SO_4. Mean of 60 Estimations 1 cc. N/10 K_2O=1.66 ccs. N/10 H_2SO_4 or 1 cc. N/10 H_2SO_4=2.82 mg. K_2O.

Using solutions of Potassium Chloride, Potassium Sulphate or Potash Alum.															
Potash Alone		In Excess NaCl.		In excess $MgCl_2$ and $CaCl_2$		In large Excess $FeCl_3$ (1.4 gms) and $AlCl_3$ (6 gms) with precipitation of $F_2(CO_3)_3$ and $Al_2(CO_3)_3$		In small amounts of $FeCl_3$ (0.1 gms) and $Al_2(SO_4)_3$ (0.5 gms) without precipitation of $Fe_2(CO_3)_3$ and $Al_2(CO_3)_3$		In excess Citric acid after neutralising with Na_2CO_3 (Potash free)			Solution of ppte. in acid $KMnO_4$ etc. 1 cc. N/10 K_2O=5.5 cc. N/10 KMnO or 1 cc. N/10 $KMnO_4$=0.855 mgK_2O	
K_2O added in mg.	K_2O found in mg.	K_2O added in mg.	K_2O found in mg.	K_2O added in mg.	K_2O found in mg.	K_2O added in mg.	K_2O found in mg.	K_2O added in mg.	K_2O found in mg.	Citric in gms	K_2O added in mg.	K_2O found in mg.	K_2O added in mg.	K_2O found in mg.
4.7	4.65	4.7	4.7	4.7	5.0	47.0	49.0	9.3	9.3	5	23.5	23.0	23.5	23.9
4.7	4.65	4.7	4.5	9.4	9.6	42.3	41.0	9.3	8.8	5	23.5	23.5	23.5	23.2
9.4	9.0	9.4	9.3	9.4	9.3	37.6	34.0	9.3	8.6	5	14.1	14.1	9.4	10.2
9.4	9.3	4.7	4.1	14.1	14.6	32.9	32.7	9.3	7.9	5	14.1	13.3	9.4	9.8
23.5	23.2	9.4	9.1	18.8	17.7	28.2	29.0	9.3	9.3	2	14.1	14.1	23.5	23.8
14.1	14.5	9.4	9.2	18.8	18.8	9.4	9.8	9.3	9.3	2	14.1	13.5	9.4	10.3
14.1	13.9	23.5	23.5	23.5	24.0	4.7	4.3	9.3	8.8	2	4.7	4.2	18.8	19.4
18.8	18.8	28.2	26.2	4.7	4.7	18.8	18.5	9.3	9.0	2	4.7	4.2	32.9	32.5
9.4	9.9	18.8	19.0			18.8	18.2	9.3	9.3					
4.7	4.9	14.1	14.3			23.5	23.0							
9.4	8.9					32.9	33.6							
18.8	18.6					32.9	32.9							
23.5	23.6													
28.2	28.2													
32.9	31.8													
37.6	36.8													
14.1	14.4													
18.8	18.8													
9.4	9.0													
4.7	4.1													
23.6	23.5													
9.4	9.3													
etc.	etc.													

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Preliminary Note on Variation of Individual Fruits of the Oil-Palm Grown Under Avenue Conditions.

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The last few years have shown that the Oil-palm can be grown as a profitable plantation crop in Malaya and that the extension of this new industry is assured, consequently an active interest is taken in this important crop by the Department of Agriculture.

As is well known, variation exists in all crops and plants and the present notes form a record of a preliminary study of variation in several characters of the fruits of the oil-palm which may prove useful in the selection of good parent palms as seed suppliers for future plantations.

The characters briefly surveyed in these notes embrace (i) weight of fruits, (ii) volume of fruits, (iii) weight of pericarp per fruits, (iv) volume of pericarp per fruits, (v) weight of nuts, (vi) volume of nuts, (vii) weight of kernel, (viii) weight of shell.

All the fruits from which these data were collected were obtained from successive palms planted in 1922 in two adjacent rows on the Government Experimental Plantation at Serdang.

Fruits were supplied from individual palms in sample lots of 25 by the Agricultural Division of the Department of

Agriculture and most of the samples from each palm were repeated two, three or more times, the repetitions being usually at intervals of several months.

The palms in one row (odd numbers) were artificially pollinated and those in the other row (even numbers) were not artificially pollinated.

The data collected from artificially pollinated palms are shown in Table I and can be compared with those collected from palms which were not artificially pollinated and which are compiled into Table II.

The figures in these Tables are taken from the records kept during the past two years but are given here to the nearest 5. The standard deviation is also calculated to the nearest 5 except for column 7 in which the nearest whole number is given. The co-efficient of variability is stated to the nearest 5%. Table III shows how the calculations were made. The remaining Tables are omitted to save space.

While most of the figures are derived from three sample lots (or seventy five fruits) further measurements from three or four more samples from each palm would have been desirable in order to embrace variations due to seasonal causes or increased maturation (since the palms are not yet in full bearing) and to render the figures more accurate.

The present figures, however, form a useful indication of the variations in the population of palms under observation though the trees are not yet sufficiently mature to enable correlations between the various characters of the fruit and the yielding ability of the palms to be made. A similar but incomplete study on fruits from 600 palms on a local commercial estate has shown that the variations indicated in these notes very closely resemble those found on palms growing under strictly commercial conditions.

The above tables (I and II) from both naturally and artifilially pollinated palms disclose average relationships for the parts of individual fruits which closely approximate the higher figures given by the Chemical Division in the Malayan Agricultural Journal, Vol. XV. 1927, page 349. It might be noted that the several parts of the fruits are in the same proportions for both means of pollination.

TABLE I.

Artificially Pollinated Palms.

	2	3	4	5	6	7		
Palm No. at Serdang.	Average weight per 25 fruits in grms.	Average volume per 25 fruits in c. cs.	Average weight of pericarp per 25 fruits.	Average volume of pericarp per 25 fruits.	Average weight of nuts per 25 fruits.	Average weight of kernel per 25 nuts.	Average weight of shell per 25 nuts.	Average volume of 25 nuts.
1	490	450	285	275	205	38	165	175
3	550	500	350	340	200	38	160	160
5	520	460	330	315	190	35	155	145
7	635	580	395	400	240	51	190	180
9	435	405	260	265	175	35	140	140
11	405	355	255	240	150	24	125	115
13	410	405	235	260	175	35	140	145
15	195	185	110	120	85	16	70	65
17	470	415	275	265	195	28	170	150
19	515	470	315	315	200	33	170	155
21	555	490	345	330	210	37	170	160
23	450	410	250	245	200	42	160	165
25	470	435	290	285	180	48	135	150
27	480	430	290	285	190	36	155	145
29	175	160	95	95	80	16	65	65
31	365	345	285	240	180	30	100	105
33	450	410	270	270	180	29	150	140
35	510	440	335	305	175	28	150	135
37	475	440	275	285	200	33	165	155
39	445	400	250	250	195	33	165	150
43	455	415	285	285	170	31	140	130

1	2	3	4	5	6	7	8	9
Palm No. at Serdang.	Average weight per 25 fruits in grams.	Average volume per 25 fruits in c. cs.	Average weight of pericarp per 25 fruits.	Average volume of pericarp per 25 fruits.	Average weight of nuts per 25 fruits.	Average weight of kernel per 25 nuts.	Average weight of shell per 25 nuts.	Average volume of 25 nuts.
47	510	465	315	305	195	38	160	160
49	460	425	280	285	180	21	155	140
51	440	385	290	265	153	19	130	120
53	400	365	260	240	140	38	105	125
55	465	425	265	270	200	30	170	155
57	535	475	345	330	190	36	155	145
59	520	490	330	340	190	23	170	150
61	410	380	215	220	195	55	140	160
63	345	300	265	190	140	34	105	110
65	540	505	330	335	210	41	170	170
67	555	485	370	335	185	34	150	150
69	320	305	185	200	135	38	95	105
71	500	470	310	315	190	32	155	155
73	365	330	215	220	150	30	120	110
75	325	325	155	175	170	39	130	150
77	365	340	225	230	140	26	115	110
79	300	280	165	170	135	33	100	110
81	385	340	200	195	185	36	150	145
83	580	510	285	275	295	65	230	235
85	450	410	230	240	220	42	175	170
Totals 41 palms	18225	16610	10905	10805	7320	1401	5920	5805
Means	445	405	265	265	180	34	145	140
Standard Deviation	100	85	65	60	40	10	30	30
Co-efficient of variability	22.5	21	24.5	22.5	21	28.5	21.5	21.5

TABLE II.

Naturally Pollinated Palms.

1	2	3	4	5	6	7	8	9
Palm No at Serdang.	Average weight of 25 fruits in grams.	Average volume of 25 fruits in c. cs	Average weight of pericarp per 25 fruits	Average volume of pericarp per 25 fruits.	Average weight of 25 nuts.	Average weight of kernels per 25 nuts.	Average weight of shell per 25 nuts.	Average volume of 25 nuts.
2	975	850	640	615	335	60	275	265
4	745	675	450	440	295	50	245	235
6	415	375	210	205	205	32	170	170
10	680	580	425	375	255	46	210	205
12	410	390	220	225	190	48	140	165
14	590	550	380	385	210	51	160	165
22	525	490	300	310	225	37	185	180
26	575	540	390	395	185	28	155	145
28	595	550	385	385	210	36	175	165
32	375	360	215	200	160	41	120	160
38	520	460	340	315	180	39	140	145
40	465	445	300	320	165	43	125	125
44	550	515	340	345	210	46	165	170
46	605	560	400	400	205	23	180	160
48	680	650	435	465	245	28	215	185
54	730	650	475	445	255	42	215	205
56	600	550	355	350	245	44	200	200
60	680	575	365	365	265	37	225	210
64	815	745	500	490	315	56	260	255
66	700	640	400	395	300	53	250	245
68	510	480	335	340	175	44	130	140

1	2	3	4	5	6	7	8	9
Palm No. at. Serdang.	Average weight of 25 fruits in grams.	Average volume of 25 fruits in c. cs.	Average weight of pericarp per 25 fruits	Average volume of pericarp per 25 fruits.	Average weight of 25 nuts.	Average weight of kernels per 25 nuts.	Average weight of shell per 25 nuts.	Average volume of 25 nuts.
70	550	535	330	365	220	38	180	170
72	685	620	480	455	205	53	155	165
74	430	400	245	245	185	33	155	155
76	710	610	420	375	290	50	240	235
78	325	295	185	180	140	33	105	115
80	550	515	350	355	200	44	155	160
84	510	460	270	280	240	60	180	180
86	630	560	325	325	305	54	250	230
Totals 29 palms	17080	15655	10465	10345	6615	1250	5360	5310
Means	590	540	360	355	230	43	185	180
Standard Deviation	145	120	95	95	50	10	50	45
Co-efficient of variability.	24.5	22	26.5	26.5	21.5	22	27	25

I. Variation in Weight of Fruits.

(a) From artificially pollinated palms.

Column 2 of Table I shows the average weights per sample of 25 fruits from 41 palms planted in a row at the Government Plantations, Serdang.

These weights are grouped in Table III which shows that the Sandard Deviation is 100 grammes per sample of 25 fruits with a mean weight of 445 grammes and that, therefore, the Co-efficient of Variability is 22.5.

The Standard Deviation is the average deviation above and below the mean weight (or volume as the case may be),

and by addition and subtraction gives the figures around which variation occurs on each side of the mean. By calculating the standard deviation as a percentage of the mean, the Co-efficient of Variability is found. This co-efficient is a useful index of the amount of variation which may be found in any particular character for purposes of comparison with variations of the same or different characters in different or in the same palms.

(b) From naturally pollinated palms.

Fruits from 29 palms growing in the open pollinated row at Serdang were examined and the data gained thereby are tabulated in Table II, column 2 of which shows the average weights per sample of 25 fruits. In this case the standard deviation is 145 grammes for a mean weight per sample of 590 grammes, and the co-efficient of variability is therefore 24.5.

Thus, for the naturally pollinated palms the variability in weight of fruits is slightly greater than it is for adjacent palms which are pollinated artificially.

It may also be noted that the average weight per sample of fruits from naturally pollinated palms exceeds that for fruits from the artificially pollinated palms by over 32%.

With regard to this difference in the size of the fruits it is perhaps unnecesary to point out that in the single row of palms which were artificially pollinated many more female flowers were reached by the abundantly sprinkled pollen causing many more fruits to set in the bunches of these palms compared with those in which pollination was not aided. There was, therefore, less crowding and more available food supply for the development of the individual fruits on the palms which were naturally pollinated as compared with the individual fruits on the artificially pollinated palms, though the total weight of fruit per palm was much higher in favour of the latter.

It must be borne in mind that these are young palms which only commenced to bear fruit in 1926 and that they are planted in a single line, whereas, had the palms been planted in the usual estate formation, the natural means of pollination would have been greatly facilitated.

In young oil-palms, variation in the fruits of artificially pollinated palms may possibly be a more reliable guide to inherent characters that the variation in the fruits of palms pollinated naturally and unevenly by chance pollen.

TABLE III.

Variation in weight of Fruits from Artificially Pollinated Palms.

Group.	Frequency.	Mean.	Deviation.	(Deviation)^2	F × d^2
645	1	= 445	200	40000	40000
545	12		100	10000	120000
445	18		0	0	0
345	8		100	10000	80000
245	0		200	40000	0
145	2		300	90000	180000
	41				$\Sigma Fd^2 = 420000$

Standard Deviation $= \sqrt{\frac{\Sigma fd^2}{N}} = \sqrt{\frac{420000}{41}} = 100$

Co-efficient of Variability $= \frac{S.\ D. \times 100}{M} = \frac{10000}{445} = 22.5\%$.

(b) *Variation in weight of Fruits from Naturally Pollinated Palms.*

Group.	Frequency.	Mean	Deviation.	(Deviation)^2	F × d^2
990	1	= 590	400	160000	160000
890	0		300	90000	0
790	2		200	40000	80000
690	6		100	10000	60000
590	10		0	0	0
490	5		100	10000	50000
390	4		200	40000	160000
290	1		300	90000	90000
	29				$\Sigma Fd^2 = 600000$

Standard Deviation $= \sqrt{\frac{\Sigma fd^2}{N}} = \sqrt{\frac{600000}{29}} = 145.$

Co-efficient of Variability $= \frac{S.\ D. \times 100}{M} = \frac{14500}{590} = 24.5\%$.

The variations in the remaining characters are compiled into Table IV, which is self explanatory. The standard deviations and the co-efficients of variability having been determined similarly to those in Table III.

TABLE IV.

Summary of Variations.

(a) = Artificial pollination. (b) = Natural pollination.

Character.		Range.		Mean.	Standard Deviation.	Co-efficient of Variability
		Min.	Max.			
Weight of fruits	(a)	175	635 grms.	445 grms.	100 grms.	22.5
,, ,, ,,	(b)	325	975 ,,	590 ,,	145 ,,	24.5
Volume of fruits	(a)	160	580 c.cs.	405 c.cs.	85 c.cs.	21
,, ,, ,,	(b)	290	880 ,,	540 ,,	120 ,,	22
Weight of pericarp	(a)	90	400 grms.	265 grms.	65 grms.	24.5
,, ,, ,,	(b)	180	640 ,,	360 ,,	95 ,,	26.5
Volume of pericarp	(a)	95	400 c.cs.	265 c.cs.	60 c.cs.	22.5
,, ,, ,,	(b)	180	615 ,,	355 ,,	95 ,,	26.5
Weight of nuts	(a)	80	295 grms.	180 grms.	38 grms.	21.
,, ,, ,,	(b)	140	335 ,,	230 ,,	50 ,,	21.5
Volume of nuts	(a)	65	235 c.cs.	140 c.cs.	30 c.cs.	21.5
,, ,, ,,	(b)	140	265 ,,	180 ,,	45 ,,	25
Weight of kernel	(a)	16	65 grms.	34 grms.	10 grms.	28.5
,, ,, ,,	(b)	23	60 ,,	43 ,,	10 ,,	22
Weight of shell	(a)	65	230 grms.	145 grms.	30 grms.	21.5
,, ,, ,,	(b)	105	275 ,,	185 ,,	50 ,,	27

While the variations outlined in these notes merely form a preliminary survey of observations made on a comparatively small number of palms growing under avenue conditions, further observations which are in progress will, in the opinion of the writers, show little material divergence from the variations now shown. This opinion is based on the results of examinations (unpublished) of fruits from palms grown under strictly commercial conditions, and, therefore, no apology is tendered for publishing these preliminary notes on variation in the characters of individual fruits from palms planted in an avenue. In the meantime, data derived from the examination of fruits from a fair population of palms grown under commercial conditions, together with records of total fruit production per palm, are being compiled.

While the practice of pollinating young palms in order to expedite crop returns is likely to continue, estates already recognise the inadvisability of continuing it unduly for physiological reasons, and, possibly, they may be influenced also by its effects on costs of collection of fruits. Experience seems to indicate that palms cannot long maintain the heavy rate of production of fruit resulting from artificial pollination except where environmental conditions are particularly favourable, unless the palms are aided by the application of suitable manures. Thus, the question of policy as regards artificial pollination becomes essentially a problem of economics, which must be tackled on all producing areas.

Records of the total weight of fruits produced annually by each of the palms in the avenue to which the notes refer, are being maintained by the Assistant Agriculturist and published each year in the Malayan Agricultural Journal

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Variations in the Amount of Ether Extract of Tuba Root (*Derris Malaccensis*, Prain).

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Introductory.

An account was given in a previous number of this Journal, Vol. XII, 1929, No. 9, page 326 of an investigation regarding the variations in the amount of ether extract of tuba root, *Derris elliptica*, Benth., of different ages, reference also being made to a further series of experiments being carried out with the other variety of tuba root commonly cultivated, *D. malaccensis*, Prain.

It is to be noted that there are two forms of the latter species, differing in their habits of growth. One form is of an erect habit, while the other is low-growing. Both forms are under cultivation at the Government Plantation, Serdang.

The present paper summarises the results obtained with the erect form which was obtained originally from Sarawak and is frequently referred to as *Derris malaccensis* (Erect Sarawak).

In this instance the individual plots at Serdang were too small to allow of the figures being used as a basis for calculating the results likely to be obtained when cultivating on a large scale and the investigation was therefore confined to a determination of the amount of ether extract in the root at varying ages.

It may be mentioned here that as a result of the increased ether extract content of the roots of this form of *D. malaccensis* larger plots have now been laid down at Serdang on which it is intended to carry out a similar investigation to that already described for *D. elliptica.*

Method of Analysis.

The harvesting of the roots, the selection of "coarse" and "fine" roots, the preparation of the sample for analysis and the determinations of moisture and ether extract were carried out in a similar manner to that described previously for *D. elliptica.*

TABLE I.

Moisture Content and Ether Extract Content of Fine and Coarse Roots of Tuba Root (*Derris malaccensis*) of Varying Ages.

Time of harvesting.	Age of roots. months.	Moisture content. per cent.	Ether extract. per cent.	Ether extract (on moisture-free basis) per cent.
A. Fine Roots.				
December 1928 ...	19	6.74	28.46	30.52
February 1929 ...	21	10.24	29.74	33.13
April 1929 ...	23	11.04	30 39	34.16
June 1929 ...	25	9.48	25.07	27.70
August 1929 ...	27	7.48	19.91	21.52
B. Coarse Roots.				
December 1928 ...	19	8.71	27.00	29.58
February 1929 ...	21	11.82	28.15	31.92
April 1929 ..	23	11.48	28.52	32.22
June 1929 ...	25	5.46	24.84	26.34
August 1929 ...	27	9.72	19.21	21.28

The analytical results for the various samples are shown in Table I.

Remarks and Conclusions.

The results of analysis show that the amounts of ether extract for both "fine" and "coarse" roots of this form of *D. malaccensis* are much greater than those for *D. elliptica* of similar age. For example, in the case of the "fine" roots the amount is on the average four times as great, while for the "coarse" roots 25 months old there is an increase of as much as eight times in the amount of the ether extract, calculated on a moisture-free basis.

The figures also show that similar to *D. elliptica* the maximum amount of ether extract for "fine" roots is obtained after 23 months, roots of greater age showing a definite decrease in this respect. The maximum figure for the "coarse" roots is also obtained at the same age.

Assuming that the amount of ether extract is a measure of the toxicity of the root the great difference in the figures for the two species points to the advisability of the establishment of standards for the valuation of tuba root based on the figure for the amount of ether extract. A premium should be paid for roots having a higher ether extract than the standard and a corresponding deduction made for those giving a figure below the standard.

It will be interesting therefore in due course to compare the yields of root obtained at varying ages since the results point to the probability of a greatly increased return per acre, provided the increased toxicity of the roots of this form of *D. Malaccensis* is recognised.

Summary.

1. The article deals with the question of the variation in the amounts of ether extract for roots of *Derris malaccensis*, (Erect Sarawak) harvested at different ages.

2. The results of analysis show that the amount of ether extract is greatly in excess of that obtained with *D. elliptica.* also that the optimum age for harvesting, as far as the above figure is concerned, appears to be when the plants are 23 months old.

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Pulasan and Rambutan Fats.

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Introductory.

An account was given in a previous number of this Journal, Vol. X, 1922, No. 9, page 222 of an investigation regarding the analytical constants of some local oils and fats of minor importance. Among these were pulasan and rambutan fats, which are obtained from the seeds of these well-known fruits.

Both fruits belong to the genus *Nephelium* (Natural Order Sapindaceae), the pulasan fruit being known botanically as *N. mutabile,* while the rambutan is *N. lappaceum.*

The results of the investigation showed that, while the analytical constants of the fats were in close agreement, the fat content of the pulasan seed was approximately double that of the rambutan seed the figures, calculated on a moisture-free basis, being 64.0 per cent. and 37.0 per cent. respectively.

In view therefore of this wide variation in fat content and of the fact that enquiries were received recently regarding the possibilities of the commercial utilisation of the fats it was considered advisable to repeat the analyses with fresh fruits obtained locally.

Both pulasan and rambutan fats are interesting from a chemical standpoint in view of both the high solidifying points of the fatty acids and the high figures for their mean molecular weights. The latter indicate the presence of glycerides of fatty acids not usually present in vegetable oils and fats.

Oil Content of Seeds.

The seeds were extracted from the fresh ripe fruits, washed from adhering pulp and dried in the sun for one day.

Both seeds are similar in appearance, being obovate in shape, and pointed at one end. Pulasan seeds are somewhat larger than rambutan, the former being approximately 1¼ inches long, ½—⅝ inch broad and ¼—⅜ inch thick, while the latter are approximately 1 inch long, ⅜ inch broad and ¼ inch thick.

A thin whitish skin covers the kernel in both cases, the flesh of the kernel being yellowish-white in colour.

The results of analysis of duplicate samples are shown in the following table :—

Seed.	Pulasan seed	Rambutan seed
	grammes.	grammes.
Average weight of seed	2.5	1.4
	per cent.	per cent.
Proportion of skin	8.5	5.6
Proportion of kernel	91.5	94.4
	100.0	100.0
Kernel.		
Moisture (loss at 100°C)	16.3	16.9
Oil (petroleum ether extract)	62.7	29.9
Residue (by difference)	21.0	53.2
	100.0	100.0
Oil (calculated on moisture-free basis)	74.9	36.0
Nitrogen (on moisture-free & fat-free residue)	5.4	1.8

Analytical Constants of Oil.

The kernels were shredded and dried, passed between rollers and pressed hot in the small laboratory hand-press.

Both fats are white solids at the ordinary temperature, melting at approximately 38°C to pale yellow oils. In each case the fat has a faintly sweetish smell.

The average results of duplicate determinations of the more important analytical constants are shown in the following table :—

	Pulasan fat.	Rambutan fat.
Fat.		
Specific gravity at 99°C (water at 15.5°C = 1)	0.8588	0.8595
Refractive index at 40°C	1.4570	1.4587
Saponification value	194.5	194.9
Iodine value (Wijs)	35.2	42.2
Unsaponifiable (per cent.)	0.3	0.5
Acid value	0.2	0.6
Fatty Acids:		
Solidifying point (Titer value)	52.8°C	56.9°C
Mean molecular weight	285.3	291.6
Neutralisation value	196.6	192.4
Iodine value (Wijs)	37.2	44.9

Remarks and Conclusions.

As regards the fat contents of the two seeds the figures confirm the results obtained previously.

The figures for the physical and chemical characteristics of the fats agree favourably with those obtained previously and published by other investigators.

Since the seeds are only available for a short period during the year and the trees are more highly esteemed for their fruit it is unlikely that either of these fats will ever be of economic importance.

Either pulasan or rambutan fat could, however, be used for edible purposes, while the high solidifying points of the fatty acids would render them both suitable in the manufacture of hard soap.

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A New Method of Drying Oil Palm Nuts.

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Introductory.

Experiments have shown that in order to crack oil palm nuts satisfactorily in a nut cracker of the centrifugal type the moisture content of the kernels should not exceed 12-14 per cent. If the kernels have a higher moisture content the result will be an increase in the percentage of both broken kernels and uncracked nuts owing to the reduction in the moisture content of the kernel having been insufficient to allow of the necessary shrinkage in the nut.

Our investigations have also shown that the moisture contents of both shells and kernels from freshly screened nuts from the centrifugal extractor are of the same order as in nuts from fresh fruits, the moisture content of the shells varying from 11 to 13 per cent. that of the kernels from 25 to 28 per cent. It is only occasionally that the figure for the moisture content of the kernels in nuts from the centrifugal extractor residue is less than the minimum figure quoted above.

The above figures show therefore that in order to effect satisfactory cracking the moisture content of the kernel must be reduced by approximately 50 per cent. Further, it will be realised that, since all this moisture must be transmitted through the shell, the problem resolves itself into a question of efficient and economic drying.

Methods of Drying.

On large oil palm estates flue gases from the boilers or sometimes from special furnaces are employed to heat continuous rotary dryers for treatment of the nuts. The temperature of such a dryer is graduated from approximately 200°C to 120°C, the moist nuts being fed into the hotter end of the dryer so that they are brought as rapidly as possible to a temperature at which they will commence to lose mois-

ture. The nuts cannot, however, be exposed to such an elevated temperature for any length of time without affecting the colour of the kernels, experiments having shown that by maintaining nuts at a temperature of 150°C for about 25 minutes a proportion of the kernels turns brown.

Such a method although giving satisfactory results is too elaborate and costly for use on small estates on which the usual practice is to dry the nuts for about 4 hours on an open kiln erected under a covered shed. The moist nuts are spread in a thin layer on iron sheets beneath which a fire is lighted, the nuts being turned over periodically in order to prevent the kernels from becoming overheated and developing a brown colour.

The drying of nuts by this method is not particularly satisfactory since too much depends on the skill of the cooly in maintaining even firing, and the proportions of broken kernels and unbroken nuts observed in some cases in the mixture coming from the nut cracker show that the method is not altogether efficient.

The method of sun-drying, which has been adopted on some estates, is also not entirely satisfactory owing to the uncertainty of the weather. While good results are obtained during a dry spell, when the nuts can be dried in 3-4 days, the accumulation of nuts during a wet spell causes delay in the recovery of the kernels.

New Method of Drying.

A new and simple method of reducing the moisture content of the kernels has recently been brought to the notice of the writer by Mr. J. Nicoll, Manager of Hopeful Estate, Batang Berjuntai. This method, which has been in use on his estate for the past three or four months, has given satisfactory results and, since a considerable saving in both fuel and labour is effected, the method has much to recommend it for general use on oil palm estates.

The method consists in stacking the moist clean nuts from the depulping screen for 10 to 12 days under a covered shed. During this period the pile of nuts becomes hot and a considerable amount of moisture is evolved which results in a reduction in the moisture content of the kernels. If a pile of nuts is examined after this period it will be noticed that

the nuts from the bottom of the pile to within 4-6 inches of the surface are dry and in many cases the kernels can be heard rattling in the shells when the nuts are shaken. The nuts to a depth of 6 inches from the surface are, however, still moist and must therefore be mixed with other nuts in the formation of a fresh pile. In this connection it is therefore suggested that it might be an advantage to stack the nuts in a space closed entirely except for ventilation holes for the escape of the moisture.

It is important to note that the period of drying indicated above should not be exceeded. In some experiments in which nuts have been stored for longer periods a large proportion of kernels has been found to be discoloured.

The nuts dried as described above crack easily, the absence of both unbroken nuts and broken kernels being particularly noticeable.

Results of Analysis.

The following table gives the results of analysis of two samples of nuts taken on different visits to the estate:—

Serial No. of sample.	Nuts from depulping screen.		Nuts from pile stacked for 10 days.	
	Moisture content of shells.	Moisture content of kernels.	Moisture content of shells.	Moisture content of kernels.
	per cent.	per cent.	per cent.	per cent.
Sample 1	13.1	27.2	12.5	13.1
Sample 2	13.2	26.6	11.5	10.5

The results show therefore that the reduction in moisture content is more than sufficient to enable the nuts to be cracked satisfactorily in a nut cracker of the centrifugal type.

In this connection it is also interesting to note that while the moisture content of the kernels shows such a considerable reduction the loss of moisture in the shell is negligible.

In order to ascertain whether any loss of oil occurred during the process, two samples of kernels were analysed. The results, which are shown in the following table, show that the figures are normal and that there is no excessive exudation of oil during the period of drying.

	Sample A per cent.	Sample B per cent.
Moisture (loss at 100°C)	11.8	11.4
Oil (petroleum ether extract)	45.4	46.6
Residue (by difference)	42.8	42.0
	100.0	100.0
Oil (calculated on moisture-free basis)	51.5	52.6

A small loss of kernel oil occurs, however, during the process of drying since if fragments of the broken shells are extracted with solvent the recovered oil contains traces of palm kernel oil as judged by the figure for the iodine value of the mixed oil. The loss of kernel oil is not serious, since it is only approximately equivalent to the amount of palm oil remaining on the surface of the nuts. Further, judging by the colour of the extracted oil, it is possible that some of the oil, calculated as palm kernel oil, may be in reality traces of organic matter from the shell extracted by the solvent.

Although during the process of drying there is a considerable evolution of moisture no marked increase takes place in the acidity of the kernel oil. For example, on one occasion samples of the nuts were taken from both the bottom and centre of a pile and the acidities of the two samples of oil expressed in the small laboratory hand-press were found to be 0.12 and 0.19 per cent. of lauric acid respectively.

Samples of the kernels have also been examined for discolouration, particular care being taken to note any kernels showing the slightest signs in this respect. In the case of one consignment 9 per cent. were found to be discoloured, in the case of another sample only 8 per cent. In view of the fact that in nearly all samples of kernels a small proportion is frequently found to be off-colour it is not thought that this relatively small increase is sufficient to affect the quality to any extent.

Remarks and Conclusions.

The results of the investigation indicate that the new method of drying affords a satisfactory and inexpensive means of drying oil palm nuts for cracking.

No expense as regards the provision of a kiln or a dryer is involved and, even though a small proportion of the kernels may be slightly off-colour, it is considered that the saving in both capital and upkeep charges will more than compensate for any small reduction in price that the buyers may offer on account of the kernels possibly falling below the somewhat vague description of fair merchantable quality.

In conclusion the writer wishes to thank both the Manager of Hopeful Estate for supplying the necessary samples and Mr. Gunn Lay Teik for carrying out the analytical work in connection with the investigation.

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The Periodic Harvesting of Sisal Hemp.

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and
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Introductory.

An account was given in a previous number of this Journal, Vol. XII, 1924, No. 11, page 352 of the possibilities of the development of a sisal hemp industry in Malaya.

It was shown that the plant (*Agave sisalana*, Perrine) was well suited to the conditions prevailing in the country, also that there was little difficulty in preparing a good quality fibre which would find a ready market, especially in view of the increasing demand for sisal fibre in the manufacture of binder twine used for the mechanical reaping of cereal crops.

Reference was also made in the paper to various experiments that were being conducted with this crop at the Government Plantation, Serdang. At the present time there are two 10-acre blocks on which cultivation experiments are being carried out, among the more important investigations being:—

(i) A comparison between bulbils and suckers as planting material.

(ii) The determination of the most suitable planting arrangement.

(iii) The optimum period for harvesting the leaves.

(iv) The preparation of fibre for valuation and sale on the London market.

The present paper concerns the third investigation and records the results of two years experiments as regards the variations in both the yield and tensile strength of fibre by harvesting the leaves at different intervals.

Planting.

A portion of one of the 10-acre blocks referred to above, Plot D, Block 23, was used for the purpose of this experiment. The area is situated on flat land, the soil consisting of a clay loam overlying a sandy sub-soil.

The area was planted during the latter part of 1924 with suckers obtained from mature plants. The suckers were planted in rows 8 feet apart and spaced 5 feet apart in the individual rows. This arrangement gives 1089 plants per acre.

It may be mentioned here that this is only one of several planting arrangements with which trials have been made at Serdang. In this connection the results to-date show that the most satisfactory method is undoubtedly a double row system, in which the plants are spaced alternately in close rows with a wide working space between each double row. Such an arrangement ensures not only a greater number of plants per acre compared with square planting but also provides increased facilities for cultivation and harvesting. For example, square planting 10 feet x 5 feet gives 871 plants per acre, but with the close rows 5 feet apart, the plants 5 feet apart in these rows and allowing 10 feet between each double row 1160 plants per acre can be obtained, an increase of approximately 33 per cent.

During the whole period of growth the land has been kept clean-weeded, no manure or lime having been applied.

Description of Experiment.

The portion of the block selected consisted of 17 rows of 39 plants. This area was divided into 9 sub-plots, each consisting of 20 alternate plants in a row, the remaining 19 plants being excluded from the experiment. There was a guard row between each row of 39 plants, while additional guard rows were included both on the sides and the ends of the experimental area.

The 9 sub-plots were divided into 3 groups of 3 sub-plots, the groups being harvested at intervals of 2 months, 4 months and 6 months respectively.

An indication of the general arrangement of the experimental area is given in the diagram on page 375.

Harvesting of Leaves.

The experiment was commenced in June 1927 when the plants were approximately 2½ years old. As a preliminary all mature leaves were removed from the plants throughout the block so as to ensure all groups being in the same condition as regards harvesting at the commencement of the experiment.

The various groups were harvested at the intervals indicated above, while the leaves from the plants in the guard rows were harvested at approximately 5 months intervals, this period having been originally selected as the cropping period for the whole of the 10-acre block.

The method adopted in selecting leaves for harvesting was to remove all those growing at an angle of 45° or less from the surface of the ground, an angle frame being used in the case of doubtful leaves.

When harvesting a sharp knife was used so as remove the leaf with a clean cut, thereby preventing damage both to the fibre near the end of the leaf and the cuticle of the leaf above. Further, the leaves were always severed as close as possible to the stem in order to ensure a maximum fibre content.

After cutting the leaves were bundled and weighed, special attention being given to these operations since in the case of this experiment the leaves had to be transported to the Department of Agriculture, Kuala Lumpur for the extraction of the fibre.

Determinations of the average length and width of the leaves were made by measuring 10 per cent. of those harvested. The results, however, afforded no indication of a general increase in either the length or width of the leaf with an increase in age of the plant except that in the case of leaves from the plots harvested every 2 months there was a tendency for the length of leaf to diminish, doubtless as a result of the too frequent harvesting. This point will be referred to again later.

In general it may be said that in the case of the other two groups the average figure for the length was approximately 48 inches, that for the width being approximately 4 inches.

Diagram of Experimental Area with Sisal Hemp at Government Plantation, Serdang.

. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .
. A . B . C . A . B . C . A . B . C .
. . . .

A = Cut two months
B = Cut four months
C = Cut six months
. = Plants not included in experiment.

Preparation and Testing of Fibre.

The fresh leaves were crushed between a pair of smooth rollers and treated in a raspador machine. The crude fibre was washed by hand in order to remove all particles of vegetable tissue. Further, in order to recover as large a proportion as possible of fibre from the leaf the residue from the raspador was also hand-picked, the leaf fragments being subsequently teased out by hand in order to recover the fibre.

The fibre was dried in the sun, brushed and weighed.

The figures for the yields of fibre from the separate groups during the two years of the experiment are recorded in Table I, the calculated yields of fibre per acre, based on the figures obtained for the groups, being added for purposes of comparison.

For the determination of the tensile strength of the fibre, bundles of 20 strands were cut to a length of 1 metre, weighed and broken in a Schopper testing machine. The length of the fibre between the jaws of the machine was fixed at 20 centimetres, 3 determinations of the breaking load being obtained with each bundle.

Sixty bundles of fibre, twenty from each sub-plot, were tested on the occasion of each cutting.

The results are shown in Table II, although in order to make the latter as concise as possible only the minimum, maximum and average figures have been entered.

Remarks and Conclusions.

With regard to the actual leaves harvested it is interesting to note in all cases during the second year of the experiment the diminution both in the number of leaves and in the average weight of leaf. The decreases are particularly noticeable in the case of leaves from the plots harvested every two months and the figures confirm those obtained in respect of length.

TABLE I.

Yields of Fibre from Sisal Hemp Leaves at Government Plantation, Serdang.

Interval between harvesting. months.	Number of leaves harvested.	Weight of leaves. lbs.	Average weight of leaf. ozs.	Weight of fibre. lbs.	Yield of fibre. per cent.	Calculated yield of fibre per acre. lbs.	Estimated recovery of No. 1 fibre per acre. lbs.
First year, June 1927-June 1928, plants 2½-3½ years old.							
2 months ...	2238	2199	15.7	81.9	3.7	1490	1270
4 months ...	2162	2355	17.4	85.5	3.6	1550	1320
6 months ...	2183	2405	17.6	88.4	3.7	1600	1360
Second year, June 1928-June 1929, plants 3½-4½ years old.							
2 months ...	1852	1483	12.8	79.8	5.4	1450	1230
4 months ...	1952	1875	15.4	107.0	5.7	1940	1650
6 months ...	2099	2242	17.1	131.6	5.9	2390	2030

TABLE II.

Tensile Strengths of Sisal Hemp Fibre from Government Plantation, Serdang.

Interval between harvesting.	Weight in grammes of 20 strands of fibre.			Breaking strain per gramme metre.		
months.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.
First year, June 1927-June 1928, plants 2½-3½ years old.						
2 months ...	0.719	0.769	0.740	21,830	24,230	23,380
4 months ...	0.722	0.771	0.752	21,900	23,000	22,420
6 months ...	0.681	0.763	0.722	23,270	24,330	23,800
Second year, June 1928-June 1929, plants 3½-4½ years old.						
2 months ...	0.665	0.800	0.736	21,130	23,200	21,940
4 months ..	0.752	0.916	0.853	20,530	23,730	21,740
6 months ...	0.843	0.941	0.892	23,350	23,530	23,440

Note.—The figures for the breaking strain have been calculated by dividing the amount of the breaking load in grammes by the weight in grammes of 20 strands of fibre.

Further, while in the case of the groups harvested at intervals of 4 months and 6 months there are considerable increases in the weights of fibre during the second year of the experiment there is an actual diminution in weight in the case of the group harvested at intervals of 2 months. This would appear to indicate that such an interval is too short to allow of adequate leaf development.

The figures for the fibre contents show in all cases a considerable increase, amounting to approximately 50 per cent, during the second year of the experiment.

With regard to the figures for the calculated yields of fibre per acre it must remembered that these refer to practically theoretical yields which would not be obtained under ordinary working conditions. The records of the figures for the different harvests show that the proportion of brushed marketable fibre varied from 80-90 per cent. of the total fibre content of the leaves and the figures in the last column of Table I have therefore been drawn up on a recovery basis of 85 per cent.

The figures for the weight per unit length of fibre during the second year of the experiment indicate that while there is a considerable increase in the average figure in this respect for leaves harvested at 4 months and 6 months intervals, the average figure for fibre for leaves harvested at two months intervals remains the same, in fact the decrease in the minimum figure would appear to indicate that there is a tendency for the average figure to diminish.

Similarly, the figures for the tensile strength indicate during the second year of the experiment a considerable decrease for fibre from leaves harvested every two months, the figures for leaves harvested at four and six months intervals being approximately constant.

A general consideration of the results to-date shows therefore that the optimum period between harvesting is 6 months. In this connection it may be mentioned that as indicated previously this period approximates to the length of the harvesting period originally selected for the 10-acre block under experiment. Further, it is found that if the leaves are left for a longer period a proportion of them is apt to bend over and become damaged.

SUMMARY.

1. The present paper records the results of certain experiments carried out during the past two years at Serdang with regard to the variations in both the yields and the tensile strengths of fibre from leaves harvested at different intervals.

2. The results to-date show that the optimum period between harvesting, judged by the figures both for yield and tensile strength, is approximately 6 months.

3. Under such conditions the estimated yields of marketable fibre during the two years of the experiment are 1360 lbs. per acre and 2030 lbs. per acre respectively.

In conclusion the writers would like to record their appreciation of the share of the work carried out as regards this investigation by Mr. R. O. Bishop, the former Ag. Agricultural Chemist, during the first year of the experiment.

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Gambier as a Catch-Crop with Oil Palm.

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Introductory.

Among possible catch-crops for cultivation with oil palms may be mentioned gambier (*Uncaria Gambir*, Roxb.) with which an investigation is being carried out at the Government Plantation, Serdang.

Since the experiments are still in progress the paper only records the yields of gambier harvested to-date, special reference being made to those obtained during a period of two years as a result of harvesting the plants at varying intervals.

Further, it is not yet possible to judge the ultimate effect of the catch-crop on the oil palms, since the latter are between 4 and 5 years old and have only recently commenced to bear fruit.

Description of Experiment.

The area for the experiment comprises one acre, Plot G of Series 3, in a 45-acre block of oil palms, Block 21. The land is flat and the soil consists of a shallow clay-loam overlying a sandy sub-soil.

The oil palms were planted during the early part of 1925, 28 feet x 28 feet triangular, this arrangement giving 63 palms per acre.

The gambier was raised from seed planted in shaded nursery beds and transferred to the field during November 1925, when the seedlings were from 3 to 4 inches high.

Three rows of gambier were planted in the avenues between the palms, the approximate width of an avenue being 24 feet. The rows of gambier were spaced 6 feet apart with the same distance between the plants in the rows. This arrangement allowed at least 6 feet between either any two gambier plants or the outer row of gambier and the adjacent row of palms.

Such a scheme of planting allows 828 plants per acre, compared with 1210 plants if the gambier had been a sole crop.

A diagrammatic representation of the plot is given on page 383.

Harvesting.

No cultivation has been undertaken since the gambier was planted except routine weeding and the return of the prunings as a mulch to the soil.

Harvesting commenced towards the end of October 1926, that is rather less than one year after planting in the field.

The method of harvesting is to top all main shoots as soon as they exceed 6 feet in height and to remove all side shoots, leaving only the pair of leaves next to the main shoot. An exception is made in the case of the side branch nearest the top of the main shoot on the outside of the plant, this branch being left as a leader.

At the commencement of the experiment the average number of stems was 6 per plant, but at the close of the second year this had been reduced to 3 per plant owing to a certain number of stems having been removed from time to time.

When harvesting gambier cutting should be delayed until the leaves are free from surface moisture. If the moist leaves are stacked for even a short period rapid discolouration ensues with consequent deterioration of product. In the case of the present investigation therefore arrangements were made not to commence harvesting until between 11 a.m. and 12 noon.

Diagram Showing Arrangement of Gambier Interplanted with Oil Palms at Government Plantation, Serdang.

```
        0     0     0     0     0     0     0
        ...........................................
A 1     ................ Gambier ..................
        ...........................................
           0     0     0     0     0     0
        ...........................................
B 1     ................ Gambier ..................
        ...........................................
        0     0     0     0     0     0     0
        ...........................................
C 1     ................ Gambier ..................
        ...........................................
           0     0     0     0     0     0
        ...........................................
A 2     ................ Gambier ..................
        ...........................................
        0     0     0     0     0     0     0
        ...........................................
B 2     ................ Gambier ..................
        ...........................................
           0     0     0     0     0     0
        ...........................................
C 2     ................ Gambier ..................
        ...........................................
        0     0     0     0     0     0     0
        ...........................................
A 3     ................ Gambier ..................
        ...........................................
           0     0     0     0     0     0
        ...........................................
B 3     ................ Gambier ..................
        ...........................................
        0     0     0     0     0     0     0
        ...........................................
C 3     ................ Gambier ..................
        ...........................................
           0     0     0     0     0     0
```

0 = Oil palm. . = Gambier.

Periodic Harvesting.

Since little definite information is available regarding the optimum period of harvesting it was decided in February 1927 to utilise the plot for the additional purpose of ascertaining the variations in yields between harvesting after different periods, those chosen being 3 months, 4 months and 6 months respectively.

Since the gambier had been planted in 9 avenues and there were three periods of harvesting it was possible to arrange for three groups to be harvested at each period, a group consisting of the three rows of plants between two rows of palms.

The groups were so arranged that between any two harvested after a given period there were always two groups which were due to be harvested after each of the other two periods. This is illustrated in the diagram referred to previously, the groups A1, A2, A3 being harvested after three months intervals, the groups B1, B2, B3 after four months and the groups C1, C2, C3 after 6 months. The object of this arrangement was to reduce possible effects of soil variations.

After periodic harvesting had been carried on for one year it was found necessary to remove the two outer rows from each group in the plot owing to the gambier plants obstructing the development of the palms.

The details for the numbers of the plants in the different groups and the figures for the annual yields of the fresh prunings are shown in Table I.

Method of Extraction.

A representative sample of 30 lbs of the fresh prunings was weighed and despatched by passenger train from Serdang to Kuala Lumpur. The bundle was received at the Department of Agriculture on the same afternoon, and the prunings spread on the floor of the laboratory till the following morning. The prunings were finely chopped and the mass weighed in order to ascertain the loss due to evaporation of moisture. The chopped material was then quartered and two samples, each weighing 5 lbs., taken for the determination of the gambier content.

In this connection it may be mentioned that the average loss between the weight of the fresh prunings and that of

TABLE I.

Annual Yields of Fresh Gambier Prunings at Government Plantation, Serdang.

Period betwen harvesting. months.	Details for individual groups.									Annual yields from series of groups.	
	Group No.	No. of plants.	Weight of fresh prunings. lbs.	Group No.	No. of plants.	Weight of fresh prunings. lbs.	Group. No.	No. of plants.	Weight of fresh prunings. lbs.	No. of plants.	Weight of fresh prunings. lbs.
A. First year, Feb. 1927–Feb. 1928, plants $1\frac{1}{4}$—$2\frac{1}{4}$ years old.											
3 months	A1	92	1931	A2	92	1348	A3	87	1259	271	4538
4 months	B1	89	1628	B2	82	1374	B3	89	1269	260	4271
6 months	C1	91	1381	C2	85	1182	C3	83	1237	259	3800
B. Second year. Feb. 1928–Feb 1929, plants $2\frac{1}{4}$—$3\frac{1}{4}$ years old											
3 months	A1	30	512	A2	31	452	A3	29	461	90	1425
4 months	B1	30	535	B2	29	502	B3	28	524	87	1561
6 months	C1	29	526	C2	28	517	C3	27	520	84	1563

the chopped material the following morning was 20 per cent. Further, it would appear that the moisture content of the fresh prunings is approximately 70 per cent.

The sample of chopped material was boiled gently for 30 minutes with 2 gallons of water in a steam-jacketed pan, the mass being turned over constantly during the process. The liquid was decanted through a coarse strainer and a further gallon of water added, the boiling being continued for 15 minutes. The liquid from the second boiling was poured through the strainer and mixed with that from the first boiling. The process was repeated a third time, one gallon of water being used and the boiling continued for 15 minutes. The exhausted prunings were thrown away and the bulked extracts returned to the pan and evaporated gently until rather less than 2 litres remained. The liquid was cooled, made up to 2 litres, filtered through a coarse paper and an aliquot portion of the filtrate evaporated to dryness, the residue being dried to constant weight at 100°C. The average of the figures for the two samples was used as the basis for the calculation of the moisture-free gambier content of the material.

It may be mentioned here that the method of calculating the gambier content on this basis was adopted on account of the wide variations found in the moisture content of the marketable product.

As pointed out in a previous article on the subject in this Journal, compare "Gambier (*Uncaria Gambir*), Its Extraction and Valuation", B. J. Eaton and R. O. Bishop, Vol. XIV, No. 2, February 1926, page 37 the above method is not the most satisfactory from the point of view of the preparation of first quality gambier. The reason for its adoption was, however, to follow as far as possible the method which would be used on an oil palm estate where the gambier was being cultivated as a catch-crop and where the management would be unwilling to incur a heavy outlay on an extraction plant.

The results of the separate determinations for the samples examined from each group are given in Table II. In order to make the latter as concise as possible only the minimum, maximum and average figures have been shown.

Remarks and Conclusions.

The results of the investigation to-date show that unless the gambier is established at the same time as the oil palms

TABLE 11.

Moisture-free Gambier Content of Fresh Cuttings from Government Plantation, Serdang.

Group No.	Interval between harvesting.	Moisture-free gambier content.			
		Minimum.	Maximum.	Average.	Average for series of groups.
	months.	per cent.	per cent.	per cent.	per cent.
A. First year, Feb. 1927–Feb. 1928, plants 1½—2½ years old.					
A1	3 months	6.6	7.4	6.9	
A2	do.	5.8	7.3	6.6	6.7
A3	do.	5.7	7.9	6.5	
B1	4 months	6.2	6.9	6.6	
B2	do.	6.4	7.5	7.0	7.0
B3	do.	7.1	7.6	7.4	
C1	6 months	6.3	6.7	6.5	
C2	do.	6.9	7.5	7.2	6.8
C3	do.	6.3	7.0	6.7	
B. Second year, Feb. 1928–Feb. 1929, plants 2½—3½ years old.					
A1	3 months	6.0	6.6	6.3	
A2	do.	6.1	7.3	6.6	6.4
A3	do.	5.3	7.2	6.3	
B1	4 months	6.1	8.4	7.2	
B2	do.	6.3	7.9	7.0	7.3
B3	do.	6.5	9.1	7.8	
C1	6 months	6.1	6.2	6.2	
C2	do.	6.4	6.9	6.7	6.3
C3	do.	5.6	6.2	5.9	

a considerable proportion, amounting in the present instance to two-thirds of the total number of plants, has to be cut out at an early date owing to the gambier obstructing the development of the palms.

Although therefore from the point of view of revenue from the catch-crop it would appear desirable to establish the gambier before the oil palms this practice would entail an additional heavy charge for the upkeep of the catch-crop, also the presence of the gambier on the land would impede the planting of the palms.

Further, the regular planting arrangement adopted in this experiment would in all probability be impracticable under estate conditions, although it is considered that the number of plants, 828 per acre, represents an average stand for gambier as a catch-crop under such circumstances.

Although the differences between the weights of fresh prunings for the separate years of the periodic harvesting experiment are not significant, the figures for the analysis of the extracts indicate an optimum period of cutting at intervals of about 4 months. It will be noticed that in both years the yields of gambier are greatest in the case of the groups harvested after this interval.

A further table, Table III, is given in which the figures for the calculated yields of moisture-free gambier during the two years of the experiment have been entered.

In view of the fact that such a large proportion of the gambier plants was removed at the end of the first year of the experiment the results for the two years cannot be considered comparable and the figures are therefore only of value from the point of view of recording the calculated amounts of moisture-free gambier for the series of groups during the individual years.

In this connection also it may be of interest to record the calculated total yields of moisture-free gambier for the various series of groups from the commencement of harvesting operations.

TABLE III.

Calculated Annual Yields of Moisture-free Gambier at Government Plantation. Serdang.

Period between harvesting. months.	Details for individual groups.									Annual yield from series of groups.	
	Group No.	No. of plants.	Weight of moisture -free gambier. lbs.	Group No.	No. of plants.	Weight of moisture -free gambier. lbs.	Group No.	No. of plants.	Weight of moisture -free gambier. lbs.	No. of plants.	Weight of moisture -free gambier. lbs.
A. First year, Feb. 1927—Feb. 1928, plants $1\frac{1}{4}$ — $2\frac{1}{4}$ years old.											
3 months -	A1	92	133.6	A2	92	89.7	A3	87	84.9	271	308.2
4 months -	B1	89	109.9	B2	82	95.7	B3	89	93.5	260	299.1
6 months -	C1	91	89.7	C2	85	84.3	C3	83	81.1	259	255.1
B. Second year, Feb. 1928—Feb. 1929, plants $2\frac{1}{4}$ — $3\frac{1}{4}$ years old.											
3 months -	A1	30	32.2	A2	31	29.9	A3	29	28.8	90	90.9
4 months -	B1	30	38.8	B2	29	35.3	B3	28	40.7	87	114.8
6 months -	C1	29	32.3	C2	28	34.3	C3	27	30.5	84	97.1

Details of groups.	Calculated yields of moisture-free gambier.			
	Oct. 1926 to Feb. 1927. lbs.	Feb. 1927 to Feb. 1928. lbs.	Feb. 1928 to Feb. 1929. lbs.	Total. lbs.
A1, A2, A3. -	98.3	308.2	90.9	497.4
B1, B2, B3. -	96.5	299.1	114.7	510.3
C1, C2, C3. -	95.0	255.1	97.1	447.2
		Total for plot		1454.9

The figures in the above table indicate that the calculated amounts of moisture-free gambier for the different groups vary only from 447 to 510 lbs., the total amount for the whole plot up to the conclusion of the second year of periodic harvesting being approximately 1455 lbs.

Although not coming within the scope of this paper it may be of interest to mention that assuming the gambier to have been planted as a sole crop the results of the periodic harvesting for the first year, during which period the plot contained the original stand of plants, indicate a total yield of fresh prunings amounting to approximately 19,500 lbs. (147 piculs) per acre, which corresponds to a yield of approximately 1330 lbs. (10 piculs) of moisture-free gambier per acre.

It will be realised that the figure for the amount of moisture-free gambier, which is based on the method of extraction previously described, approximates to a theoretical yield, which would not be obtained in ordinary practice. With such a comparatively simple process however it appears reasonable to assume that 90 per cent. of the soluble solids would be recovered, thereby reducing the figure for the yield of moisture-free gambier obtained under estate conditions to approximately 1200 lbs. (9 piculs) per acre.

SUMMARY.

1. The present paper records the results of an investigation extending over a period of two and a half years regarding the cultivation of gambier as a catch-crop with oil palm.

2. The yields of both fresh prunings and moisture-free gambier obtained during this period are given.

3. The results of a periodic harvesting experiment appears to indicate that the optimum period for harvesting is at intervals of 4 months.

4. The investigation is still in progress and further results will be reported at the end of a further year's work.

In conclusion, the writers wish to record their appreciation of the share of the work performed during the first year of the investigation by Mr. R. O. Bishop, the former Acting Agricultural Chemist.

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Kepayang Oils.

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Introductory.

Kepayang is the Malay name for the oils obtained from the seeds of two different plants, *Pangium edule*, Reinw. and *Hodgsonia capniocarpa*, Ridley. The former is a tall spreading tree belonging to the Natural Order, Flacourtiaceae, while *Hodgsonia capniocarpa* is a forest creeper which belongs to the Natural Order, Cucurbitaceae.

Pangium edule is known as pokok kepayang to differentiate it from *Hodgsonia capniocarpa* which is called akar kepayang, although according to Gimlette (1) the more correct name for the latter is 'akar klapayang.

Accounts have been given in two previous numbers of this Journal, Vol. II, 1913-1914, No. 3, page 67 and Vol. XI, 1923, No. 2, page 39 of the oil from the *Hodgsonia* species, the oil from *Pangium edule* has not previously been investigated in the Department. In the second article referred to above the results of an analysis of a sample of fruits alleged to be *Pangium edule* are recorded but, since the oil content of the kernel was so low and there was insufficient oil for a determination of the physical and chemical characteristics, the figures must be regarded as inconclusive.

Since a further enquiry was received recently regarding the possibility of the utilisation of kepayang oil on a commercial scale the investigation has been repeated, authentic specimens of both fruits being kindly supplied for the purpose by the Forest Department.

(1) Gimlette J.D. Malay Poisons and Charm Cures, page 140.

POKOK KEPAYANG (*Pangium edule*, Reinw.)

The fruits are oblong-ovoid in shape and vary from 7 to 12 inches in length and 4 to 6 inches in cross-section. The fresh ripe fruit weighs from 3 to 4 lbs. The rind of the fruit is brown in colour, woody and wrinkled.

The fruits may contain from 20 to 30 seeds, which are embedded in a slimy pulp. This pulp darkens rapidly on exposure to air, doubtless owing to the presence of a tannin.

The individual seeds are brownish in colour and approximately triangular in shape, they are about 2 inches long. The veined shell is thin, tough and is approximately ⅛ inch in thickness.

The kernel is white in colour but, similar to the pulp, darkens rapidly on exposure to air.

OIL CONTENT OF SEEDS.

The results of analysis are shown in the following table:—

Seed.		grammes.
Average weight of seed	...	14.4
Average weight of kernel	...	8.7
		per cent.
Proportion of shell	...	39.3
Proportion of kernel	...	60.7
		100.0
Kernel.		
Moisture (loss at 100°C)	...	44.5
Oil (petroleum ether extract)	...	24.8
Residue (by difference)	...	30.7
		100.0
Oil (calculated on moisture-free basis)		44.7
Oil (calculated on whole seed)	...	14.8

Analytical Constants of Oil.

Owing to the small number of seeds available it was not possible to prepare by expression a sufficient quantity of the oil for the determination of the more important analytical constants. The kernels were therefore shredded, dried and solvent extracted with petroleum ether.

The oil was yellow in colour and had a somewhat pleasant odour.

The average results of duplicate determinations of the more important analytical constants are shown in the following table.

Oil.

Specific gravity at 30°C (water at 15.5°C = 1) ...	0.9132
Refractive index at 30°C ...	1.4660
Saponification value ...	196.5
Iodine value (Wijs) ...	108.3
Acid value ...	0.2
Unsaponifiable (per cent.) ...	0.6

Fatty Acids.

Solidifying Point (Titer value) ...	20.4°C
Mean molecular weight ...	280.3
Iodine value (Wijs) ...	111.1

Remarks and Conclusions.

The results of analysis show that the oil content of the kernels, calculated on a moisture-free basis, is approximately 45 per cent., equivalent to about 15 per cent. on the fresh seeds.

The figure for the iodine value of the oil indicates that the latter belongs to the class known as semi-drying oils.

An interesting feature of the oil is that it is optically inactive. This is all the more surprising since the genus *Pangium* is closely allied to the genus *Hydnocarpus*, both belonging to the same Natural Order, and the optical activity of the oils from seeds of the genus *Hydnocarpus* is well-known.

During the preliminary drying of the kernels an odour of hydrocyanic acid was noticeable. According to Gimlette (2) this has been observed by previous investigators, notably Greshoff, who showed the presence of a cyanogenetic glucoside. In this connection also it may be mentioned that the toxic properties of the fresh seeds are well-known to the Malays who have been known to use both the freshly crushed seeds and the oil from such seeds as poisons.

The presence of the glucoside would therefore cause the seeds to be regarded with a certain amount of suspicion, since special treatment would be required to ensure the oil being non-poisonous.

An additional interesting feature of the kernel is the presence of a tannin causing an intense darkening of the material on drying.

AKAR KEPAYANG (*Hodgsonia capniocarpa*, Ridley)

The fruits are similar in shape to small melons, being approximately 6 inches in diameter and 4 inches high, A fresh ripe fruit weighs from 2 to 3 lbs.

The rind of the fruits is dark greyish-green in colour and smooth, the surface being however marked by small globular depressions.

The individual fruits contain from 4 to 6 seeds, the latter being embedded in a slimy pulp. The fresh seeds form approximately 20 per cent of the weight of the ripe fruit.

The seeds are buff in colour, ellipsoid in shape and flat, the surface being marked by sunken veins. The shell is tough, woody and is approximately $\frac{1}{8}$ inch in thickness. The seeds are about 3 inches long and from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches wide.

The kernels, which are covered with a thin layer of spongy tissue, are yellowish-white in colour, soft and oily.

(2) Gimlette J.D. Malay Poisons and Charm Cures, page 202.

Oil Content of Seeds.

The results of analysis are shown in the following table:

Seed.	grammes.
Average weight of seed	... 29.0
Average weight of kernel	... 9.6
	per cent.
Proportion of shell	... 55.0
Proportion of spongy layer	... 12.0
Proportion of kernel	... 33.0
	100.0

Kernel.	
Moisture (loss at 100°C)	... 46.3
Oil (petroleum ether extract)	... 35.7
Residue (by difference)	... 18.0
	100.0
Oil (calculated on moisture-free basis)	... 66.5
Oil (calculated on whole seed)	... 11.8

Analytical Constants of Oil.

The fresh kernels were dried in order to reduce the moisture content. They were shredded and the mass pressed in the small laboratory hand-press.

A faint odour of hydrocyanic acid was noticed during the early stages of drying, indicating the presence of a glucoside similar to that present in *Pangium edule*.

The oil is light yellow in colour with a pleasant nutty odour. After standing for a few days a small quantity of stearin separates.

The following table gives the average results of duplicate determinations of the physical and chemical characteristics of the oil, the figures for the sample examined previously being added for purposes of comparison.

Oil.	Present sample.	Previous sample.
Specific gravity at 30°C (water at 15.5°C = 1) ...	0.907	0.922 20°C)
Refractive index at 30°C ...	1.4613	1.4694 (20°C)
Saponification value ...	201.2	203.9
Iodine value ...	67.1	63.6
Acid value ...	3.6	5.6
Unsaponifiable (per cent.) ...	0.4	

Fatty Acids.		
Solidifying point (Titer value)	42.1°C	40.8°C
Mean molecular weight ...	272.6	272.7
Iodine value ...	68.2	61.9

Remarks and Conclusions.

The results of analysis show that the oil content of the kernels, calculated on a moisture-free basis, is approximately 66.5 per cent. This figure compares favourably with that obtained on the previous occasion, 65.6 per cent.

The figures for the physical and chemical characteristics of the oil and the fatty acids, which are in close agreement with those published previously, show that the oil is entirely different in character from that obtained from *Pangium edule*. The iodine value of the oil indicates that it belongs to the non-drying class.

Utilisation of Kepayang Oils.

Since neither plant has been cultivated under estate conditions and there is no reliable information available with regard to the yield of fruit it is not possible to give an idea of the economic possibilities.

It is true that the oils are used by the Malays as a substitute for coconut oil for cooking purposes but, since the crop in each case is definitely seasonal and neither oil appears to possess any special feature to enhance its value, it is extremely unlikely that the cultivation of the crop on an estate scale will be undertaken. Further, it must be remembered that it would also be necessary to subject the kernels to special treatment before extraction in order to obviate the presence of any glucosidal principle in the oil.

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The Destructive Distillation of Coconut Shells and Oil Palm Nut Shells.

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The present paper describes certain experiments carried out at the Department of Agriculture regarding the destructive distillation of the shells of nuts from the coconut palm and the oil palm.

The work was originally undertaken with the idea of investigating the possibility of utilising the surplus amounts of coconut shells on some estates but in view of the fact that the oil palm fruit contains a similar constituent it was decided to extend the experiments to include oil palm nut shells.

With regard to the latter, surplus amounts of this material are never likely to be available since oil palm nut shells constitute a valuable part of the fuel supply for the estate factory.

When such materials are heated in a closed space in the absence of air decomposition ensues resulting in the formation of charcoal and in the evolution of large quantities of volatile products which can be recovered only by using an efficient retort and condensing plant.

If charcoal alone is required it is sufficient to carbonise the shells in a stack or pit. The enclosed heap is fired and when the shells are thoroughly burning the supply of air is cut off, carbonisation proceeding without further combustion. This primitive method is capable of producing good charcoal.

On certain coconut estates this method is simplified still further by merely throwing water on a burning heap of shells. This results, however, in a charcoal which is not uniform and is of an inferior quality.

Coconut charcoal is used on estates as a fuel in suction gas engines, but on account of the dust associated with the char-

coal special scrubbers are desirable to purify the gas before admitting to the cylinders in order to avoid pitting.

Apart from this use there is only a very limited demand for either of these charcoals, the two main uses being as decolourising agents for liquids and absorbents for noxious gases. For example, during the Great War coconut shell charcoal was used on an enormous scale in the filling of respirators, but naturally this demand has now shrunk to very small limits.

Description of Plant and Process.

The plant in which the experiments were conducted consists of a cylindrical iron retort closed by an iron door, the retort being mounted horizontally in a brick-work chamber and heated by the hot gases from the furnace below.

The retort is 3 ft. in length and 2 ft. in diameter and holds from 250 to 300 lbs of material.

From the top of the retort a horizontal pipe leads to a water-cooled vertical condenser, from which there is an ascending pipe to carry away the non-condensible gases for combustion in the furnace. Such an arrangement suffices to recover all condensible products.

When carrying out a carbonisation, distillation commences from 2 to 3 hours after firing and frequently continues for as long as 30 hours. At the commencement the distillate consists principally of water but, as carbonisation proceeds, increasing quantities of other substances, partly in solution and partly in suspension, distil over with the water. Tar passes over in suspension during the later stages settling out when the condensed liquid is allowed to stand.

The dissolved substances consist chiefly of acetic acid, methyl alcohol (wood spirit) together with much smaller quantities of more or less complex organic substances, for example, aldehydes and phenols. This crude liquid is usually termed pyroligneous acid.

Treatment of Distillate.

Although it will be realised that the separation of pure products from the distillate is a matter of specialised technique

it may be interesting to describe briefly the general method employed.

After mechanical separation of the tar the pyroligneous acid is redistilled from a still in order to eliminate dissolved tar and tarry condensation products, the residue in the still being completely freed from acetic acid by the injection of steam. The redistilled liquid, which contains all the acetic acid and methyl alcohol, is neutralised with lime and partially redistilled to recover the methyl alcohol, leaving the acetate of lime in solution. The latter is evaporated to dryness in pans, the residue forming the commercial product known as grey acetate of lime.

To prepare acetic acid this material is treated in a special still with sulphuric acid and the crude acetic acid distilling over further purified by rectification.

The weak solution of methyl alcohol is rectified, the resulting spirit being further purified by treatment with caustic soda. In this way wood spirit, which is almost water-free and which contains no impurity other than a small proportion of acetone, can be recovered. A small quantity of wood oil separates during the rectification of the crude methyl alcohol solution but this oil is of little importance.

An outstanding feature of the tar is its fluidity due to the presence of much higher proportions of valuable liquid products than are found for example in wood tar.

The tar is heated in an iron retort fitted with a condenser. Water held in suspension distils first, then a quantity of clear red oil, leaving a small residue of pitch in the retort. The pitch has no value other than as fuel.

The oil which consists principally of phenols, commonly described as creosote, yields after purification with caustic soda an almost colourless liquid.

Results of Experimental Distillations.

The following table gives the results of two distillations carried out in the experimental plant described previously. In order to make the table as simple as possible the figures have been calculated to show the amounts of the various pro-

ducts derived from 100 lbs. of shells although in both cases the amount of material distilled was approximately 300 lbs.

Nature of Product.	Coconut palm shells.	Oil palm nut shells.
Charcoal ...	49.0 lbs.	33.4 lbs.
Pyroligneous Acid ...	2.88 gallons	3.11 gallons
Tar ...	0.26 gallon	0.43 gallon
Pyroligneous Acid		
Acetic acid (calculated) ...	4.68 lbs.	3.38 lbs.
Methyl Alcohol (Wood Spirit) ...	0.07 gallon	0.04 gallon
Tar		
Crude creosote oil ...	0.13 gallon	0.19 gallon

It must be understood that the above figures can only be regarded as a guide to the amounts of the various products that would be ordinarily obtained, these amounts being dependent both on the original moisture content of the shells and the manner of firing the retort.

Description of Charcoals.

Coconut charcoal is hard and brittle; the outside surface is dull on account of the charred fibrous layer, but the broken surface is glossy. Pieces of coconut charcoal properly carbonised emit a ringing sound when dropped on a hard surface, but imperfectly carbonised material found among the estate product gives a dull sound. The specific gravity of coconut charcoal varies from 1.17 to 1.21, compared with 1.30 for the original shell (water = 1).

Oil palm nut charcoal resembles coconut charcoal externally, but exhibits a much more glossy appearance when fractured. A remarkable feature of this charcoal is its high specific gravity which reaches 1.47 compared with 1.30 for the original shell (water = 1).

Remarks and Conclusions.

The results of the experiments show that coconut shells give a higher yield of charcoal than oil palm nut shells, which in turn give a higher yield than hard woods, such as mangrove, the average figure for the latter being 25 per cent.

Coconut charcoal offered for sale in the local market competes with imported and local mangrove charcoal. Some samples of estate coconut charcoal compare unfavourably in quality with the wood charcoal, although since coconut shells are in reality a waste product the resultant charcoal can be sold at a lower price. An improvement in the method of carbonisation is therefore the only means of producing a charcoal of uniform superior quality.

Although several bye-products from the destructive distillation of these shells can be recovered as described it is not suggested that these products can be marketed on a small scale. The initial cost of a plant would be considerable and further the same products are already being manufactured for export on a large scale in other countries.

Apart from this consideration coconut shells form a valuable source of supply of acetic acid, creosote for wood preservation, and wood spirit for use either as a denaturant for alcohol or in the preparation of pure methyl alcohol.

Oil palm nut shells give a higher yield of creosote but as stated before these shells are unlikely to be available in any quantity for destructive distillation.

In conclusion the writers wish to acknowledge the assistance received from the Manager of Chersonese Estate, Kuala Kurau, Mr. H. Hansen of Teluk Merbau Estate, Sepang, and Mr. E. A. O. Simpson of Elmina Estate, Sungei Buloh for supplies of material for distillation.

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Physomerus grossipes F. (Coreidae. Hemiptera-Heteroptera). A Pest of Convolvulaceae and Leguminosae.

BY

N. C. E. MILLER.

Physomerus grossipes F. a member of the family Coreidae, of the Order Hemiptera-Heteroptera is an abundant species in Malaya where it is found on Convolvulaceous and Leguminous plants.

The gregarious habits of this "bug" throughout the life cycle render it conspicuous, and, in addition, greatly facilitate control.

When it occurs in large numbers, the damage caused by its method of feeding,—i.e. piercing the stems and sucking the juices—is considerable, for plants thus attacked, speedily wilt and wither, while fruits fail to develop, or decompose before reaching maturity.

DISTRIBUTION.

This insect has been recorded from the following localities:—

Dist. Bengal; Calcutta; Moorshedabad, (Ind. Mus.); Sikhim; Assam; Margherita, (Atkinson Coll.); Khasi Hills (Chennell); Bombay, (Leith); Ceylon, (Dohrn); Nicobar Islands, Camorta (Coll Dist.): Burma; Metanja, Palon, (Fea); Malayan Archipelago (1).

HOST PLANTS.

The following plants of which the Malay names of some are given in brackets, are attacked by both nymphs and adults:—

Morning Glory *Ipomaea purpurea* Roth. Sweet Potato *Ipomaea Batatas* Lam. (Keledek), *Ipomaea reptans* Poir. (Kang Kong); Cowpea, *Vigna Catjang* Walp. (Kachang merah, K. panjang, K. tange, K. perut ayam, K. puteh); *Clitoria Ternatea* L. (Bunga biru, Kachang telang) and French bean

Phaseolus vulgaris (Kachang bunchis, K. pendek) (2). It has also been recorded on *Citrus* sp. (Limau), but the evidence of its actually feeding on this plant is not reliable. The writer has frequently noticed, in the field, that *P. grossipes* will oviposit on plants which are definitely not its foodplants, and also on other objects such as tree trunks or wooden palings. Possibly therefore it has happened that this plant has been added to the list of previously recorded foodplants of *P. grossipes* merely because its ova have been found thereon.

Description.

Ovum. (Fig. 1.) When first deposited, the colour of the ovum is pale greenish copper, becoming dark bronze green shortly afterwards.

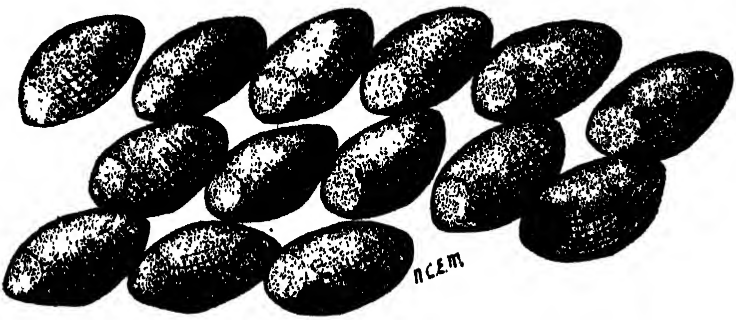


Fig. 1. Ova. Natural size 1.60 mm. × 1.00 mm.

The surface is shining and strongly reticulate, except near the micropylar area, where it is almost smooth.

The shape is irregularly ovate. The ovum is flattened on the side in contact with the surface on which it is laid. The flattened surface has a feeble, longitudinal depression.

Length 1.60 mm. width 1.0 mm.

1st. instar Nymph. (Fig. 2.) Antennae ferrugineous, with the apex of each segment paler; apical segment with a dense pale brownish pubescence.

Eyes, dark brick red.

Vertex, clypeus shining olive green; ventral surface of head pale greenish amber; rostrum pale amber, with the apex of the segments dark brown; epicranial suture pale amber.

Nota dark shining olive green, with the median suture pale amber; sternites pale amber, suffused with olive green.

Segments 1, 2, and 3 of the abdomen dorsally greenish ochraceous with a pale reddish suffusion, and a somewhat indistinct median longitudinal reddish stripe; remaining segments greenish ochraceous with a reddish or reddish orange suffusion. Dorsal plates brown. Segments 1 and 2 of the abdomen ventrally pale greenish ochraceous; remaining segments pale greenish ochraceous with a faint reddish suffusion; spiracular area reddish orange; spiracles ferrugineous.

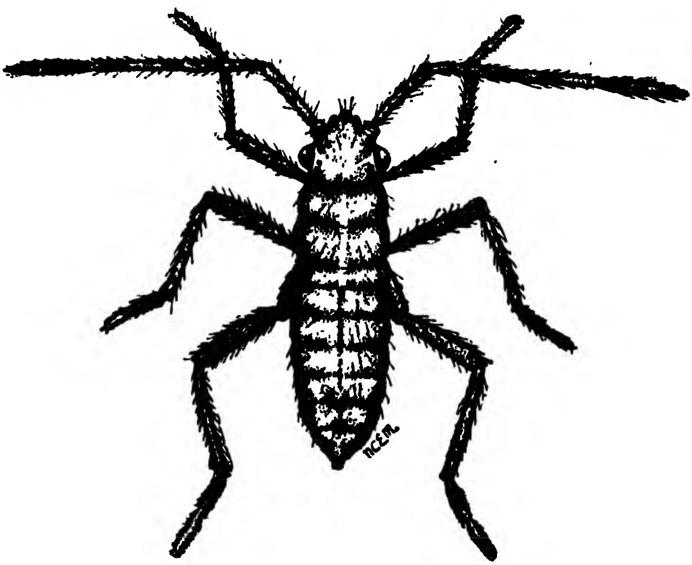


Fig. 2. 1st instar nymph. Natural size 2.50 mm.

Legs pale olive green, irregularly suffused with dark olive green.

Elongate, elliptical. Apical segment of antennae fusiform, finely pubescent; all segments of the antennae with scattered setae; basal segment feebly curved.

Legs moderately robust and setose; femora feebly tuberculate on the anterior margin near the apex.

Head and body feebly setose; pronotum with a median tubercle on the anterior margin; rostrum reaching to the middle of the posterior coxae.

Total length 2.5 mm.

Length of antennal segments.

1.	2.	3.	4.
.50 mm.	.70 mm.	.65 mm.	.75 mm.

2nd. instar Nymph. (Fig. 3.) Segments 1, 2 and 3 of the antennae shining black with the base and apex narrowly pale ochraceous; apical segment black with a fine pale brown pubescence.

Eyes dark red.

Clypeus, and antenniferous projections dark shining olive green; vertex ochraceous, with a faint reddish suffusion; epicranial suture dark olive green.

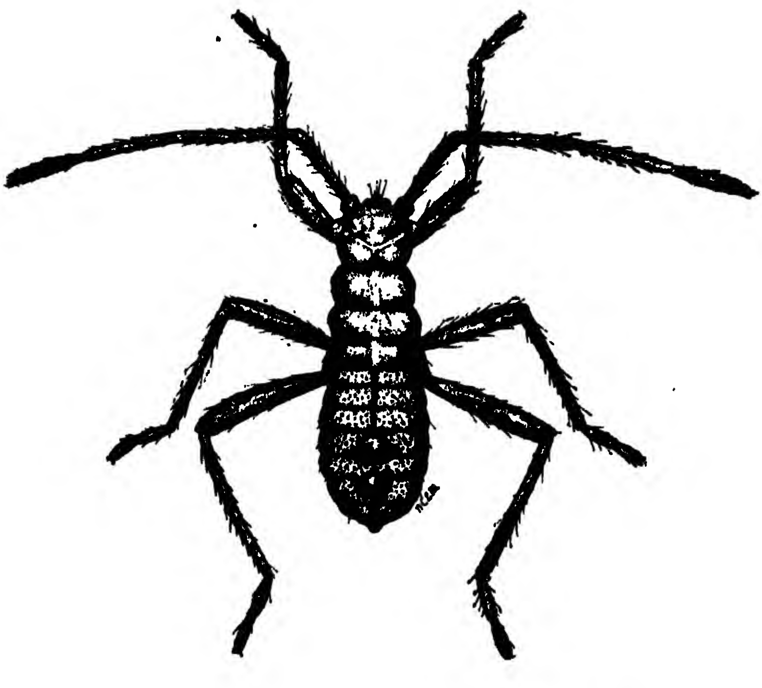


Fig. 3. 2nd instar nymph. Natural size 3.00 mm.

Pro and mesonotum ochraceous with a pale ochraceous median longitudinal suture and a faint ~~olive~~ green suffusion; metanotum shining dark olive green with the median suture pale ochraceous, and with the lateral margins ochraceous; median tubercle on pronotum shining black; pro and meso

sternum pale greenish ochraceous; metasternum shining olive green.

Abdomen dorsally pale greenish ochraceous, with an ochraceous patch around the dorsal plates, and with an irregular reddish maculation and suffusion and a median longitudinal reddish stripe; connexivum ochraceous; dorsal plates shining black.

Ventral surface of head ochraceous or greenish ochraceous.

Ventral surface of abdomen ochraceous with a fine and irregular reddish maculation; spiracles dark ferrugineous.

Rostrum pale greenish ochraceous with the apical segment broadly suffused with dark olive green apically, and the remaining segments with a faint olive green suffusion apically.

Coxae greenish ochraceous with the outer apical margin faintly reddish; trochanters shining olive green; legs dark greenish black.

Similar in shape to the 1st. instar nymph.

Total Length 3 mm.

Length of antennal segments.

1.	2.	3.	4.
.85 mm.	1.10 mm.	1.00 mm.	1.00 mm.

3rd. instar Nymph. (Fig. 4.) Immediately after ecdysis the colouration of the nymph in this instar is, as follows.—Antennae, rostrum and legs violaceous. Head and body very pale violaceous. In an hour or so the nymph assumes the following colours.

Apical segment of antennae dark ferrugineous; 1st. 2nd. and 3rd. segments of antennae shining dark blackish brown.

Eyes dark crimson.

Clypeus, antenniferous projections, anterior area of vertex shining black; posterior area of vertex light brown; epicranial suture whitish, with the lateral arms suffused with light brown; rostrum pale whitish brown, irregularly suffused with dark brown.

Tubercle on the anterior margin of the pronotum, black; pronotum pale reddish brown almost entirely suffused with black, and with the lateral and posterior margins black: median sulcus pale brownish white; mesonotum light reddish brown with a blackish ovate marking; median sulcus whitish faintly maculate with ferrugineous; metanotum blackish, with the lateral areas pale reddish brown; median sulcus whitish, irregularly and somewhat faintly maculate with ferrugineous,

Abdomen dorsally whitish, with the connexivum pale reddish brown, the dorso-lateral area suffused with bluish grey, and the whole surface irregularly spotted with ferrugineous; segments 1 - 4 and 6 and 7 with a moderately broad, ill defined median longitudinal ferrugineous stripe; segments 8, 9 and 10 dark brown; dorsal plates blackish with an orange and reddish orange suffusion on the anterior margin; ventral surface of abdomen whitish, suffused with bluish grey and strongly and irregularly maculate with ferrugineous;

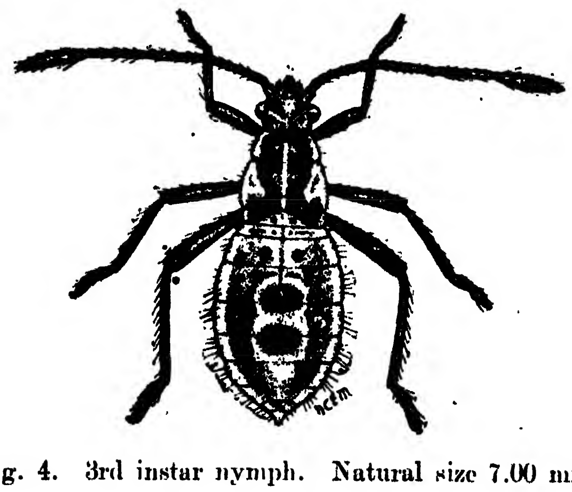


Fig. 4. 3rd instar nymph. Natural size 7.00 mm.

Sternites whitish, suffused with pink.

Legs dark shining blackish brown. Head, body, legs and antennae with scattered short setae many of which on the head and body are covered with a white wax like substance.

In this instar, the rudiments of the hemelytra and wings are perceptible, otherwise there are only slight differences between it and the preceding instar. The 1st. segment of the

abdomen is well covered, laterally, by the developing wings, and the rudiments of the scutellum are to be seen.

Total length. 7 mm.

Length of antennal segments.

1.	2.	3.	4.
1.20 mm.	1.60 mm.	1.30 mm.	1.20 mm.

4th. instar Nymph. (Fig. 5.) Antennae and legs dark shining blackish brown.

Eyes dark crimson.

Head and dorsal surface of thorax and abdomen black: connexivum pale reddish orange.

Ventral surface of thorax and abdomen black, with a dull gloss; body strongly setose, most of the setae being covered with a white wax like substance.

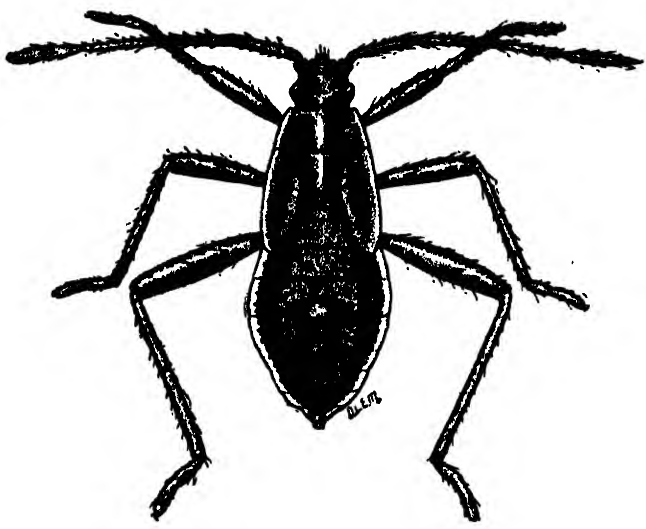


Fig. 5. 4th instar nymph. Natural size 7.90 mm.

The rudiments of the hemelytra in this instar are well defined, and reach just beyond the posterior margin of the 2nd. abdominal segment. The developing wings are almost concealed by the hemelytra. The tubercle on the anterior margin of the pronotum is considerably reduced.

Total length 7.90 mm.

Length of antennal segments.

1.	2.	3.	4.
1.60 mm.	2.30 mm.	1.90 mm.	1.70 mm.

5th. instar Nymph. (Fig. 6.) Shortly after ecdysis the antennae are violaceous; head dark greyish green; epicranial suture pale greenish; vertex with a median longitudinal pale greenish stripe before the epicranial suture.

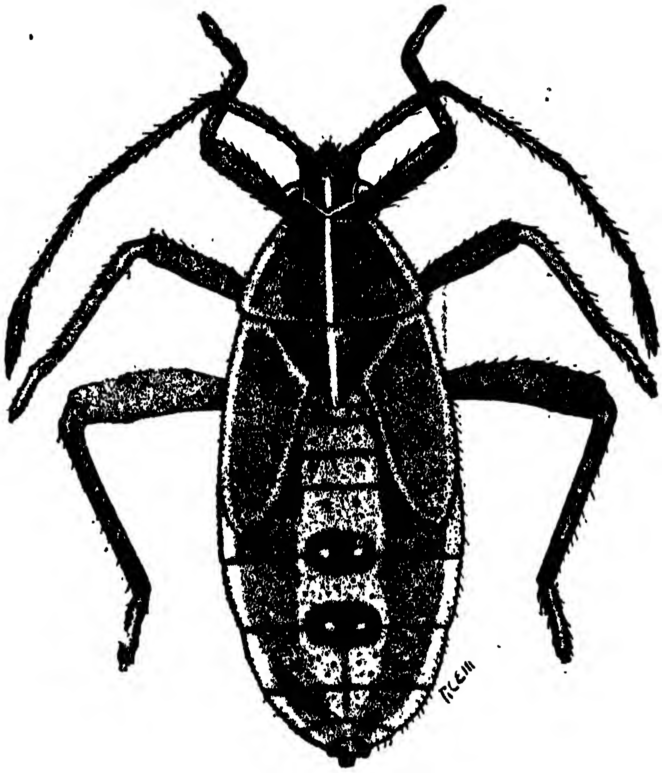


Fig. 6. 5th instar nymph. Natural size 12.50 mm.

Eyes dark ferrugineous.

Pronotum greyish with an orange suffusion on the posterior half laterally; median suture pale orange; mesonotum greyish with the median suture whitish; pro and mesonota with an irregular red maculation.

Rudiments of hemelytra dark olive green, with the outer margins pale orange and the inner margins irregularly suffused with pale greenish ochraceous.

Rudiments of wings dark olive green.

Abdomen dorsally greyish; connexivum orange; dorso-lateral area dark bluish grey; tubercles dark red; dorsal plates brownish orange.

Sternites whitish with a fine reddish maculation.

Ventral surface of abdomen greyish, darker near connexivum; segment 6 to apical segment dark grey; tubercles dark red.

After a few hours the colouration of the nymph becomes much darker dorsally.

Ventrally the darkening is not so pronounced.

The rudiments of the hemelytra reach almost to the posterior margin of the 4th. abdominal segment. The posterior femora are more incrassate and tuberculate than in the previous instar, and the tubercle on the anterior margin of the pronotum is absent. The rostrum reaches to the base of the 1st. abdominal segment.

Total length. 12.50 mm.

Length of antennal segments.

1.	2.	3.	4.
2.30 mm.	2.60 mm.	3.10 mm.	2.30 mm.

Adult. Male. (Fig. 7.) Antennae dark blackish brown: Eyes dark brown.

Head dark blackish brown with a faint and irregular light brown suffusion on the vertex; rostrum dark blackish brown.

Pronotum black with a median longitudinal light reddish brown stripe which is more pronounced on the basal two thirds; lateral margins narrowly and almost entirely light brown or reddish brown.

Scutellum black, with the apex light brown, the lateral margins dark brown and with a light brown median longitudinal stripe on the basal half.

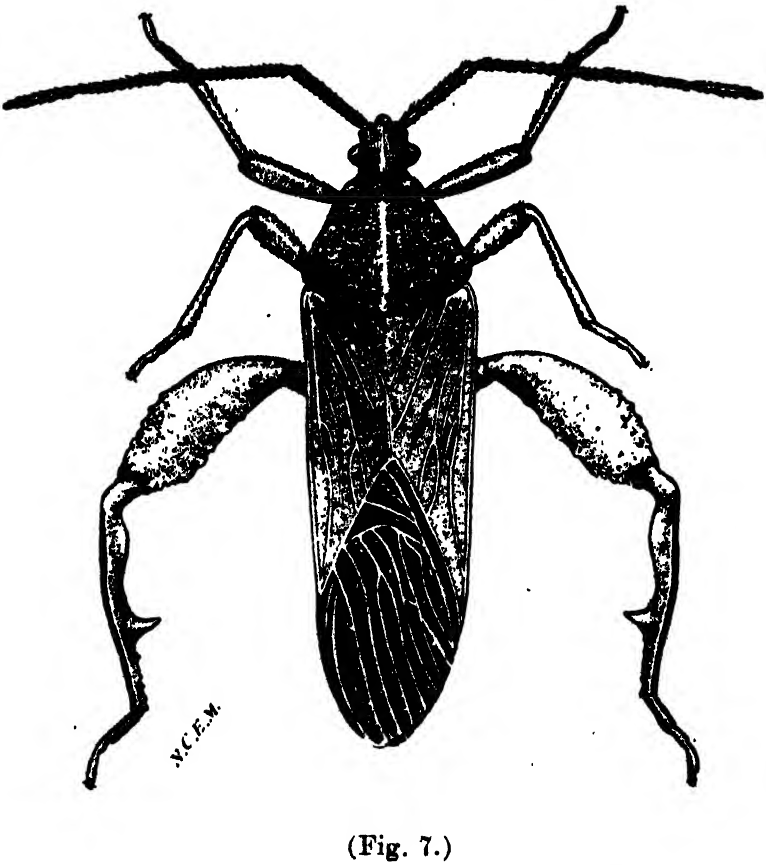
Meso and metanota pale shining brown.

Sternites blackish brown, with shining black tubercles.

Abdomen dorsally brownish orange with an irregular dark brown suffusion and with the 7th. segment almost entirely black; connexivum pale brownish orange; ventral surface of abdomen blackish brown; with the connexivum light brown.

Tubercles on ventral surface of abdomen shining piceous; spiracles black.

Legs shining black, with a light brown pubescence.



(Fig. 7.)

Outer and apical margin of corium and basal margin of clavus light brown; corium and clavus dark blackish brown; membrane dark infumate with a faint iridescence.

Wings dark purplish black with the basal half of the costa light brown and the connecting membrane shining reddish orange.

The whole insect except the dorsal surface of the abdomen, membrane of hemelytra and wings, with the pubescence covered with a whitish wax-like substance giving it a greyish appearance.

Basal segment of antennae thicker than remaining segments. Dorsal surface of pronotum rugose and tuberculate.

Sternites rugulose with scattered rounded and flattened tubercles.

Ventral surface of abdomen finely rugulose, tuberculate; segments 2 and 3 with a number of large mucronate tubercles irregularly disposed with the apices inclined towards the apex of the abdomen.

Tibiae of anterior and median legs somewhat compressed laterally, and with a feeble sulcus along the anterior surface; posterior femora strongly incrassate and irregularly tuberculate on the anterior and lower surface, the tubercles being more pronounced and in some cases mucronate, near the apex; posterior tibiae sinuate, laterally compressed, with a sulcus along the anterior surface and with a robust spine about half-way along the inner margin. Below this spine is a shorter spine, and thence the inner margin is spinose to the apex.

Dorsal surface of the abdomen smooth. The dorsal plates which were prominent in the nymphal stages are now flattened and have the appearance of integumental folds.

Rostrum reaching median coxae in some individuals. Occasionally it reaches about half way between anterior a median coxae.

Adult. Female. Similar to the male, but differs in the following respects.

The posterior femora are less robust and the tubercles less prominent.

The posterior tibiae have no median projection on the inner margin. The tubercles on the 1st. to the 3rd. segments of the abdomen ventrally are less numerous and flattened. None of the tubercles on these segments is mucronate.

Average total length.		Average length of antennal segments.			
	Male.	1.	2.	3.	4.
	17.20 mm.	2.82 mm.	3.70 mm.	2.73 mm.	2.62 mm.
Maximum.	21.50 mm.	3.50 mm.	4.00 mm.	2.90 mm.	2.80 mm.
Minimum.	14.00 mm.	2.40 mm.	3.00 mm.	2.10 mm.	2.30 mm.
Difference.	7.50 mm.	1.10 mm.	1.00 mm.	.80 mm.	.50 mm.
	Female.				
	18.03 m.m.	2.71 mm.	3.40 mm.	2.70 mm.	2.60 mm.
Maximum.	21.00 mm.	3.20 mm.	4.00 mm.	3.10 mm.	3.00 mm.
Minimum.	15.00 mm.	2.50 mm.	3.20 mm.	2.50 mm.	2.40 mm.
Difference.	6.00 mm.	.70 mm.	.80 mm.	.60 mm.	.60 mm.

Width between pronotal angles.

	Male.	Female.
Average.	5.38 mm.	5.36 mm.
Maximum.	6.00 mm.	6.20 mm.
Minimum.	4.80 mm.	4.80 mm.
Difference.	1.20 mm.	1.40 mm.

The above figures are based on the measurements of fifteen individuals.

Specimens taken in the field were slightly larger. One hundred individuals, fifty males and fifty females, were examined and the results of the measurements are given now.

Average total length.		Average length of antennal segments.			
	Male.	1.	2.	3.	4.
	21.52 mm.	3.32 mm.	4.11 mm.	2.98 mm.	2.87 mm.
Maximum.	22.50 mm.	4.00 mm.	4.50 mm.	3.10 mm.	3.00 mm.
Minimum.	17.00 mm.	2.90 mm.	3.40 mm.	2.50 mm.	2.30 mm.
Difference.	5.50 mm.	1.10 mm.	1.10 mm.	.60 mm.	.70 mm.

	Female.				
	21.08 mm.	3.07 mm.	3.81 mm.	2.85 mm.	2.79 mm.
Maximum.	21.80 mm.	3.50 mm.	4.00 mm.	3.00 mm.	2.90 mm.
Minimum.	19.00 mm.	2.80 mm.	3.10 mm.	2.50 mm.	2.40 mm.
Difference.	2.80 mm.	.70 mm.	.90 mm.	.50 mm.	.50 mm.

Width between pronotal angles

	Male.	Female.
Average.	6.04 mm.	5.95 mm.
Maximum.	6.50 mm.	6.20 mm.
Minimum.	5.00 mm.	5.40 mm.
Difference.	1.50 mm.	.80 mm.

Life History.

The ova of *P. grossipes* are deposited in batches, in varying numbers up to one hundred or so, on the upper or lower sides of the leaves, or on the stems of the foodplants. Frequently, also, they have been discovered on other plants, in the vicinity of the foodplant.

There is generally no definite arrangement of the ova, but, it has been observed that they are sometimes deposited in narrowly separated parallel rows.

The female insect generally remains on the batch of ova, or close by, for some days after the eclosion of the nymphs, all of which crowd together on the foodplant.

The incubation period lasts from seventeen to twenty one days, the average being 17.5 days.

Under field and laboratory conditions, the gregarious habit of this bug has been observed to continue throughout life, from the day of eclosion, up to, and including the adult stage, and it is a factor which contributes to the difficulty of recording with absolute accuracy the duration of the nymphal stages, for, it was found that individuals separated from a batch and placed singly, for the purposes of observation in breeding cages or tubes died within a few days of being removed. The adults, if disturbed are able to eject from the anus an objectionable whitish yellow fluid, to a distance of a foot or so.

At the time of ecdysis, the nymph firmly attaches its legs to the plant it is feeding on, and hangs head downwards. Then, by convulsive movements, it causes the skin, which is to be got rid of, to split along the epicranium and the nota. The antennae and the anterior pair of legs are the first to be released. Then, with these legs, the bug is now able to obtain a firm hold on another part of the plant and to extricate the other pairs of legs and the abdomen.

Postembryonic development, as is usual with the Rhynchota is gradual, and, apart from the nymphs' being very pale in colour immediately following ecdysis, colour changes are not very pronounced.

The most marked change in colour takes place at the 3rd. instar.

As regards morphological changes, the most noticeable are those which take place in the fifth moult when the insect becomes adult. In this stage, the hemelytra and wings are fully developed, and, if the dorsal surface of the abdomen be examined, it will be seen, that the dorsal plates have degenerated, their former position being indicated by small integumental folds only.

Under laboratory conditions the average duration of the nymphal stages is as follows:—

1st. instar.	7. days.
2nd. instar.	8.70 days.
3rd. instar.	8.30 days.
4th. instar.	14.60 days.
5th. instar.	22.90 days.

Adults lived for 32.3 days and the total life cycle from the ovum to the death of the adult is approximately 113 days or 16 weeks. Nine adults captured in the field lived, under laboratory conditions, an average of 30.8 days. On pages 419, 420 will be found a table giving the figures for the duration of each instar of the individuals which were reared in the laboratory, and which form the subject of the present paper.

An examination of this table shows that the greatest variations in the duration of a particular instar, are in the fourth, fifth and adult instars. Abnormally short durations of the lives of nymphs and adults are generally due to some

injury received shortly after, or during ecdysis, when the moulting insect is frequently unable, from some cause or other, to entirely free itself from the exuviae, consequently it is difficult or even impossible for it to walk about and begin to feed. If it is unable to liberate the mouth parts, of course, feeding is quite out of the question.

Adults of *P. grossipes* exhibit several characters which permit differentiation to be made between the sexes, without difficulty.

The males differ from the females, in having much more robust hind femora. The hind tibiae, on their inner surface, have a prominent spine which is not present on the hind tibiae of the female. In small male specimens the tibial spine and the hind femora are frequently feebly developed.

On the first, second and third ventral segments of the abdomen of the male (Fig. 8.) the tubercles are much more pronounced and some of them are mucronate while, in the female all the tubercles are flattened or feebly rounded.

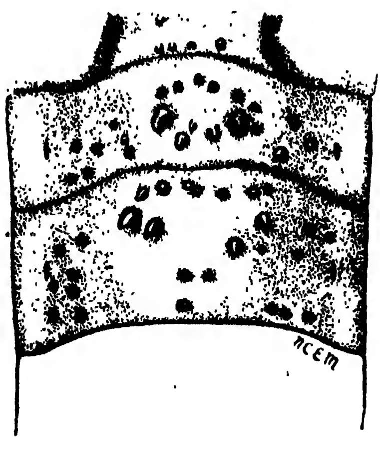


Fig. 8. Segments 1, 2 and 3 of abdomen, ventorally, of male.

Parasites.

Up to the present, only one parasite of *P. grossipes* has been recorded, but it has not yet been specifically determined It is a Hymenopteron belonging to the superfamily Chalcidoidea.

Control.

Control measures may be directed against all stages of this insect.

The ova are conspicuous and thus may be collected and destroyed with trouble.

When the nymphs and adults are to be dealt with, it will be found that the best method is to shake them from the foodplant into large tins containing water on which is a film of kerosene.

The adults are more active during the warmer periods of the day, therefore it is advisable to start operations against them in the early morning, when they are sluggish and less ready to take to flight when disturbed.

Spraying with kerosene emulsion is also effective in destroying the nymphs and adults, but it is not recommended for bugs which are feeding on vegetables e.g. Kang-Kong, or leguminous plants of which the pods are used for human consumption.

Conclusion.

The writer is indebted to Che Mohamed Yusope for keeping the breeding registers.

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Received for publication 1st August, 1929.

Number.	1	2	3	4	5	6	7	8	9	10	11
Sex.	♀	♀	♀	♀	♀	♀	♀	♀	♂	♀	♀
Date of oviposition -	29.10.28	29.10.28	29.10.28	29 10.28	11.11.28	11.11.28	14.11.28	14.11.28	14.11.28	14.11.28	14.11.28
Date of hatching -	15.11.28	15.11.28	15.11.28	15.11.28	30.11.28	30.11.28	1.12.28	1.12.28	1.12.28	1.12.28	1.12.28
Incubation period	17	17	17	17	19	19	17	17	17	17	17
Date of 1st moult -	22.11 28	22.11.28	22.11.28	22.11.28	5.12.28	5.12.28	7.12.28	7.12.28	7.12.28	7.12.28	7.12.28
Period of 1st instar -	7	7	7	7	5	5	6	6	6	6	6
Date of 2nd moult -	3.12.28	3.12.28	3.12.28	3.12.28	14.12.28	16.12.28	14.12.28	15.12.28	15.12.28	15.12.28	15.12.28
Period of 2nd instar -	11	11	11	11	9	11	7	8	8	8	8
Date of 3rd moult -	10.12.28	10.12.28	10.12.28	10.12.28	19.12.28	19.12.28	21.12.28	24.12.28	24.12.28	24.12:28	24.12.28
Period of 3rd instar -	7	7	7	7	5	3	7	9	9	9	9
Date of 4th moult -	18.12.28	18.12.28	18.12 28	18 12.28	28.12.28	30.12.28	4. 1.29	7. 1.29	7. 1.29	7. 1.29	14. 1.29
Period of 4th instar -	8	8	8	8	9	11	14	14	14	14	21
Date of 5th moult -	19.1.29	21. 1.29	22. 1.29	24.1.29	29. 1.29	6. 2.29	22. 1.29	22. 1.29	22. 1.29	22. 1.29	22. 1.29
Period of 5th instar -	32	34	35	37	32	37	18	15	15	15	8
Date of death of adult	25.1.29	9. 2.29	18. 2.29	18. 2.29	27. 3.29	8. 5.29	23. 1.29	29. 1.29	8. 2.29	30. 1.29	7. 5.29
Life of adult -	6	19	27	25	57	91	1	7	17	8	105

Number.	12	13	14	15	16	17	18	19	20	21
Sex.	♀	♀	♀	♂	♀	♀	♀	♀	♂	♀
Date of oviposition -	14.11.28	14.11.28	14.11.28	17 11.28	17.11.28	17.11.28	16.11.28	16.11.28	17.11.28	17.11.28
Date of hatching -	1.12.28	1.12.28	1.12.28	3.12.28	3.12.28	3.12.28	7.12.28	7.12.28	5.12.28	5.12.28
Incubation period -	17	17	17	16	16	16	21	21	18	18
Date of 1st moult -	7.12.28	7.12.28	7.12.28	8.12.28	8.12.28	8.12.28	20.12.28	20.12.28	15.12.28	15.12.28
Period of 1st instar -	6	6	6	5	5	5	13	13	10	10
Date of 2nd moult -	15.12.28	15.12.28	16.12.28	17.12.28	17.12.28	17.12.28	24.12.28	24.12.28	25.12.28	26.12.28
Period of 2nd instar -	8	8	9	9	9	9	4	4	10	11
Date of 3rd moult -	24.12.28	24.12.28	24.12.28	28.12 28	28.12.28	28.12.28	30.12.28	30.12.28	29.12.28	7. 1.29
Period of 3rd instar -	9	9	8	11	11	11	6	6	4	12
Date of 4th moult -	14. 1.29	14. 1.29	14. 1.29	14. 1.29	14. 1.29	14. 1.29	14. 1.29	14. 1.29	26. 1.29	26. 1.29
Period of 4th instar -	21	21	21	17	17	17	15	15	28	19
Date of 5th moult -	22. 1.29	22. 1.29	22. 1.29	29. 1.29	4. 2.29	4. 2.29	18. 2.29	18. 2.29	21. 2.29	22. 2.29
Period of 5th instar -	8	8	8	15	21	21	35	35	26	27
Date of death of adult -	7. 4.29	28. 2.29	28. 2.29	27. 2 29	22. 2.29	18. 3.29	28. 2.29	28. 2.29	6. 3.29	16. 4.29
Life of adult -	75	37	37	29	18	42	10	10	13	53

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Megymenum brevicorne F. Pentatomidae. (Hemiptera-Heteroptera) A Minor Pest of *Cucurbitaceae* and *Passifloraceae*.

BY

N. C. E. MILLER.

Megymenum brevicorne first described by Fabricius in 1787, is a moderately large blackish "bug" belonging to the *Pentatomidae* or "shield bugs," a family included in the Order *Hemiptera—Heteroptera*.

The type of the genus *Megymenum*, which is distributed in the Oriental Region and in Australasia, is *M. dentatum* Boisd. This species occurs in New Guinea, whence it was first recorded. (1). (2).

M. brevicorne is rarely found in large numbers, therefore, for the present it may be accorded the rank of a minor pest.

DISTRIBUTION.

In addition to being found in Malaya. *M. brevicorne* has been recorded as occurring in the following localities:—

Khasi Hills (Chennell); Calcutta (Ind. Mus.); Burma; Rangoon, (Fea); Nicobar Islands, (Coll. Dist.); and it is also reported from China. (1.)

HOST PLANTS.

Up to the present, the nymphs and adults have been noticed as feeding on the following plants only. Grenadilla *Passiflora quadrāngularis* L. (Mal. Timun hutan, T. belanda);

Pumpkin *Cucurbita maxima. Duch.* (Mal. Labu ayer, L. manis, Mendelikai; Semangka); Snake gourd *Trichosanthes anguina* L. (Mal. Ketola ular). (3). It is likely that other species of these genera are also attacked.

The stems and fruits are the parts of the plant preferred by this "bug."

CONTROL.

The most simple method of dealing with this species is to collect the adults or nymphs in the early morning, by shaking them off the plants on which they are feeding, into a tin containing water with a film of kerosene on the surface.

The ova, although not very conspicuous may be discovered without undue labour and destroyed by crushing.

DESCRIPTION.

Ovum. Fig. 1. Cylindrical, tapering very feebly at each end; surface very finely punctate and covered with a whitish silky or wax-like substance.

Pale whitish green, turning to reddish before the eclosion of the nymph.

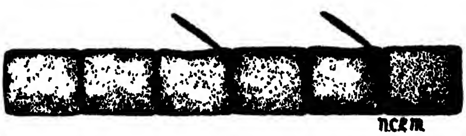

Fig. 1. Ova. Natural size 1.00 × .80 mm.

1st. instar nymph. Fig. 2. On emergence from the ovum, the nymph is pinkish dorsally, with the exception of abdominal segments 1, and 6 to 9 which are whitish. The abdomen ventrally is whitish with a fine pink maculation. In a short time, the nymph assumes the colours given in the following description.

Antennae light brown, suffused with pink.

Eyes light red.

Head, amber with a faint reddish suffusion on the vertex; outer margins of the juga, and margins of the projections in front of the eyes, reddish.

Nota, amber, with the lateral margins whitish and translucent.

Abdomen, dorsally, whitish with a pink suffusion on the lateral margins of the second segment; segments 3—7 almost entirely suffused with pink; segments 2—7 with a fine black maculation; lateral projections on segments 1—8 white, translucent; lateral projections on remaining segments amber; chitinized plates, on middorsum of abdomen, amber, darkest on segments 1—5; ventral segments of abdomen whitish, suffused with pink and with a fine blackish maculation.

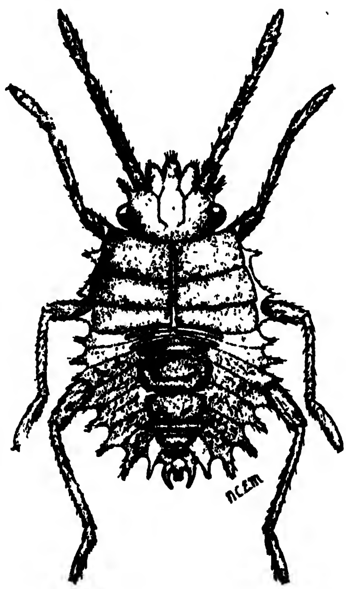

Fig. 2. 1st instar nymph. Natural size 2.30 mm.

Ventral surface of head, rostrum and sternites amber,

Femora and tarsi amber; tibiae very pale amber with a pink suffusion along the inner margin.

Elliptical. Antennae robust and with scattered setae.

Head with a projection in front of the eyes; juga and tylus feebly setose.

Thorax and abdomen with the lateral margins produced, flattened and mucronate; margins of lateral projections very feebly tuberculate and setose.

Legs, robust; femora and tibiae feebly setose, the setae arising from low tubercles.

The abdominal segments dorsally have chitinised plates, of various shapes, three of which, i.e., those on segments 3, 4 and 5 bear the pores of the odoriferous glands. The forms of these dorsal plates are, as follows;—Segment 1. narrow, oblong and feebly arcuate; segment 2. oblong and feebly arcuate; segment 3, fusiform; segment 4, trapeziform with the lateral margins and anterior margin feebly convex; segment 5, similar to that on 4 but narrower; segment 6, concavo-convex, with the anterior margin concave; segment 7 narrow, trapeziform, with lateral margins convex; segment 8, plano-convex, with the anterior margin straight; segment 9, quadrate with the lateral margins feebly rounded.

Total length. 2.30 mm.

Length of antennal segments.

1.	2.	3.	4.
.25 mm.	.40 mm.	.39 mm.	.60 mm.

2nd. instar nymph. Fig. 3. Antennae and head light p ceous.

Eyes dark red.

Nota whitish, almost entirely suffused with dark brown; apex of projections on lateral margins of pro and meso nota dark brown; projections on metanotum entirely whitish.

Abdomen, dorsally whitish, with all the segments except segment 1, suffused with dark brown; lateral projections on all segments except 1 and 8 suffused with dark brown in the basal half; dorsal plates on mid dorsum of abdomen, brown.

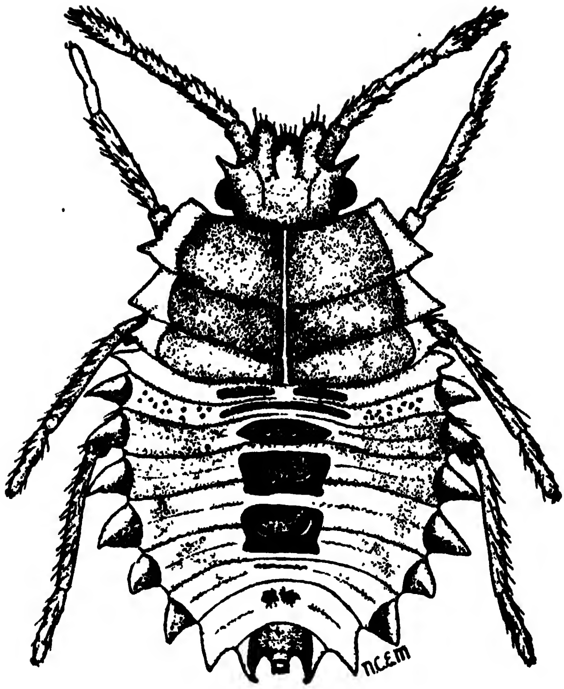

Fig. 3. 2nd instar nymph. Natural size 4.00 mm.

Ventral surface of head blackish brown; rostrum pale olive.

Sternites brownish, suffused with black;

Ventral surface of abdomen whitish, with a faint brownish maculation and a brownish suffusion on segments 5--8 medially.

Femora pale olive green; tibiae and tarsi greenish white.

The form assumed by the nymph in this instar, is similar to that of the 1st. instar, but is more rounded. The dorsal plates of abdominal segments 1 and 2 are irregular and those on segments 7—8 indistinct.

Total length. 4 mm.

Length of antennal segments.

1.	2.	3.	4.
.30 mm.	.60 mm.	.50 mm.	.60 mm.

3rd. instar nymph. Fig. 4. On eclosion, the antennae are violaceous, the eyes dark red, the head pale greenish with a violaceous suffusion along the outer margin of the juga and on the vertex. The projections in front of the eyes are reddish violaceous.

Nota, whitish, with a strong reddish maculation and a deep olivaceous suffusion towards the lateral margins.

Abdomen, dorsally, whitish with a ferrugineous suffusion and maculation, and with an orange suffusion and maculation on each side of the middorsum of segments 1 and 2.

The nymph becomes more darkly coloured in about three hours, and then the nota are strongly maculate with brown and dark olive green.

Dorsally, the abdominal segments are suffused and maculate with dark olive green, the suffusion being most pronounced on segments 3—6.

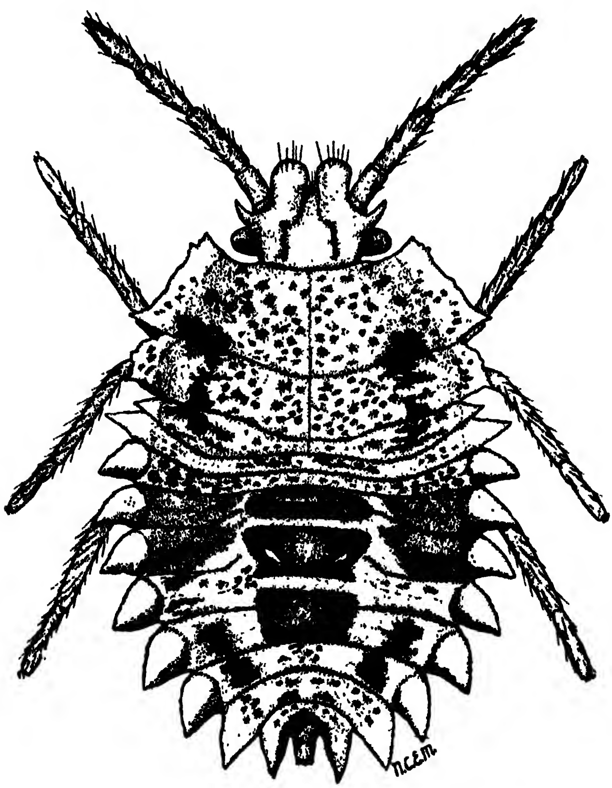

Fig. 4. 3rd instar nymph. Natural size 5.00 mm.

Segments 2 and 3 of the antennae of the 3rd. instar nymph are somewhat compressed dorso-ventrally, and the eyes more elongate than those of the nymphs of the preceding instars.

The outer margin of the pronotum is somewhat concave, and the dorsal plates are absent from abdominal segments 1 and 2 and 6 to 9. The dorsal plate on the 3rd. segment becomes oblong, with the lateral margins rounded.

The head and body are powdered with a white wax like substance.

Total length. 5 mm.

Length of antennal segments.

1.	2.	3.	4.
.40 mm.	.80 mm.	.70 mm.	.85 mm.

4th. instar nymph. Fig. 5. Antennae blackish brown. Eyes dark red.

Head light brown, with a dark brown maculation on the juga and a dark brown suffusion on the vertex.

Pro and meso nota whitish, strongly maculate and blotched with dark brown and black; metanotum whitish with some light and dark brown spots.

Abdomen dorsally whitish, strongly maculate and suffused with black and brown, the suffusion being most pronounced on segments 3, 4 and 6; dorsal plates light brown with a black maculation and suffusion; lateral projection on abdomen except on segments 1 and 8, with a moderately broad black border, suffused with light brown along its anterior margin, along their posterior margins; ventral surface of abdomen pale brownish white strongly maculate with brown and black and with an irregular longitudinal black stripe near the inner margins of the spiracles; spiracles black.

Pro and meso sterna pale brownish white, with a black confluent maculation; meta-sternum pale brownish white, with a large irregular black patch.

Ventral surface of head and thorax finely powdered with a white wax like substance.

Femora and tarsi dark olive green; tubercles on femora blackish; tibiae pale bluish green immediately after ecdysis. A day after ecdysis the femora and tibiae become whitish with the tubercles dark brown, and the tarsi become brownish.

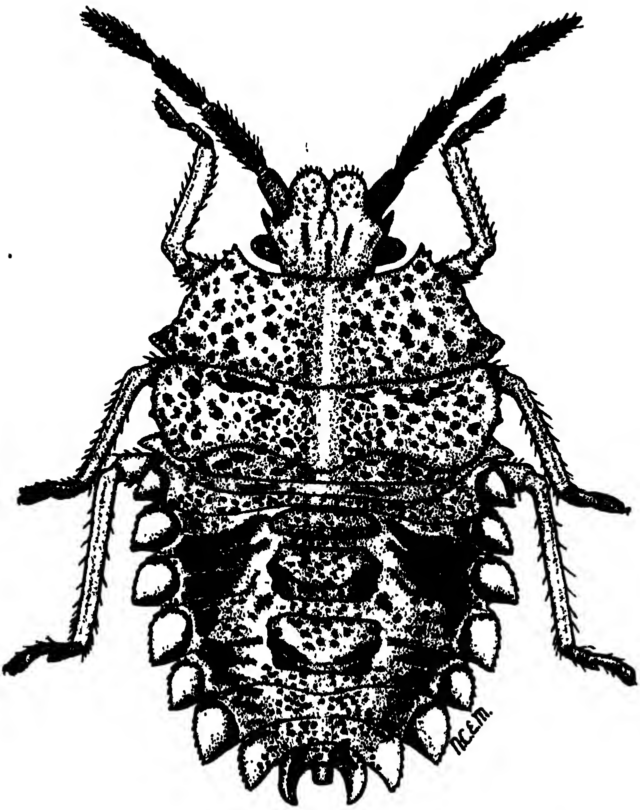

Fig. 5. 4th instar nymph. Natural size 7.00 mm.

The principal points of difference between the 4th. instar nymph and the 3rd. instar nymph, are, the approximation of the inner margins of the juga, and the narrowing in length and breadth of the meta-notum, of which the lateral margins are rounded, and do not have a mucronate projection. The posterior margin of the mesonotum is strongly sinuate, and that of the metanotum almost straight.

Total length. 7 mm.

Length of antennal segments.

1.	2.	3.	4.
.60 mm.	1.30 mm.	1.05 mm.	.90 mm.

5th. instar nymph. Fig. 6. Antennae blackish brown with a faint violaceous suffusion at the base of each segment

Eyes dark ferrugineous.

Vertex brownish ochraceous, strongly maculate with black, most of the spots being coalescent; juga with two longitudinal black patches at the base.

Pronotum brownish ochraceous, strongly maculate with black, and with some light brown spots along the median line; near the anterior angles the spots coalesce very strongly, forming a dark patch; on each side of the median line is a pale brownish crescentic marking.

Rudiments of scutellum and hemielytra ochraceous with a fairly dense black maculation, and irregular dark brownish patches.

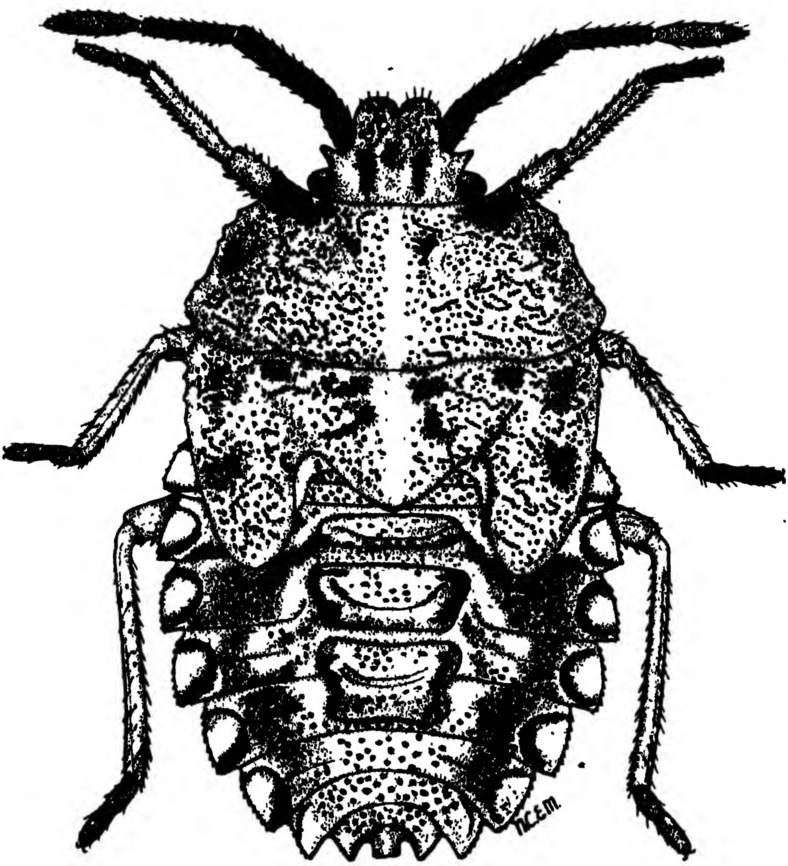

Fig. 6. 5th instar nymph. Natural size 10.50 mm.

Dorsal surface of abdomen whitish ochraceous, very strongly maculate with black and with an irregular, almost immaculate area around the dorsal plates; lateral projections on abdomen with a blackish crescentic marking on the inner margin.

Femora greyish, with a black maculation; tibiae brownish, with a dark brown maculation; tarsi blackish brown.

Sternites whitish ochraceous with a coalescent black maculation.

Ventral surface of abdomen whitish ochraceous, with a strong black maculation which is very dense and coalescent along the inner margin of the spiracles. Spiracles black.

The nymph of the 5th. instar presents the following features which distinguish it from the nymph of the 4th. instar. The inner margins of the juga are almost completely fused. The metanotum is almost concealed by the scutellum and the rudiments of the hemielytra reach just beyond the basal margin of the 4th. abdominal segment. The lateral projections on the 2nd abdominal segment are almost entirely concealed by those on the 1st abdominal segment.

The spines on the femora are more robust.

Total length. 10.50 mm.

Length of antennal segments.

1.	2.	3.	4.
.70 mm.	1.60 mm.	1.30 mm.	1.20 mm.

Adult. Fig. 7. Eyes dark ferrugineous.

Whole body, except the membrane of the hemielytra, wings, and dorsal surface of the abdomen, cupreous black. and lightly covered with a whitish ochraceous wax-like substance. Membrane of hemielytra ochraceous, somewhat infuscated beyond the middle. Venation on membrane brownish.

Connexivum with pale brownish ochraceous spots. Dorsal surface of abdomen dark reddish brown, slightly paler basally and greyish on the lateral margins near the apex.

Ventral surface of whole insect rather more thickly covered than the dorsal surface, with the whitish wax-like substance. Spiracles shining piceous.

Legs black. Wings infumate.

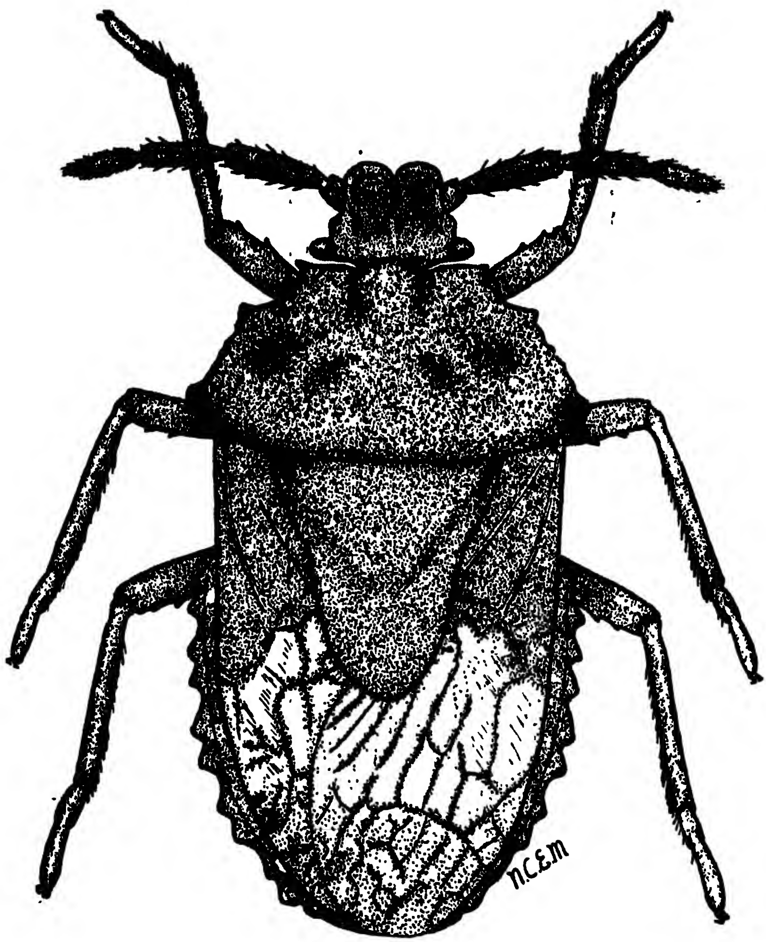

Fig. 7. Adult ♂. Natural size 10.73 mm.

Elliptical. Segments 2 and 3 of the antennae somewhat compressed dorso-ventrally; segment 2 with a feeble longitudinal sulcus near the posterior margin; surface of segments 1, 2 and 3 longitudinally striate and with scattered short setae; segment 4, fusiform, strongly hirsute with the surface of the basal third longitudinally striate, and of the apical two thirds smooth or very finely punctate, shining.

Head strongly depressed anteriorly; lateral margins rounded or rotundato angulate before the eyes; surface strongly rugose punctate.

Surface of pronotum strongly and irregularly punctate and rugose, with irregular depressions and with a rounded tumescence, about a third as broad as the anterior margin near the anterior margin, at its centre; anterior margin sinuate, produced laterally; lateral margins strongly concave in the apical third and almost straight but irregular in the basal two thirds; posterior margin broadly rounded.

Scutellum strongly and irregularly punctate, irregularly impressed, rounded apically and with a deep elongate depression on each side of the base.

Corium finely striate and irregularly punctate.

Connexivum punctate; lateral projections of connexivum rounded.

Ventral surface of abdomen strongly and irregularly punctate.

Area around odoriferous gland apertures on meta sternum rugose.

Femora with mucronate processes on the posterior margin near the apex. Tibiae feebly longitudinally sulcate and strongly setose on the posterior margin, the setae being longer and more robust near the apex.

Average total length.

	Male.	Female.
	10.73 mm.	12.46 mm.
Maximum.	11.50 mm.	14.00 mm.
Minimum.	10.00 mm.	11.80 mm.
Difference.	1.50 mm.	2.20 mm.

Length of antennal segments.

	1.	2.	3.	4.
Male.	.60 mm.	1.60 mm.	1.40 mm.	1.20 mm.
Female.	.90 mm.	2.1 mm.	1.50 mm.	1.40 mm.

Life History.

The female *Megymenum brevicorne* deposits her ova in a chain, end to end. They are fairly thickly covered with a whitish wax-like substance in the form of fine threads and small granules.

The ova are laid on the upper or lower sides of the leaves, or on the stems of the foodplant.

Eighteen, was the greatest number of ova deposited in the laboratory by a single female.

The nymphs emerge by forcing up the circular operculum which is situated on the upper side at one end of the ovum. A few hours before the time of hatching, the embryo nymph may be seen through the chorion of the ovum, which then has a reddish appearance.

At the time of hatching the nymph is pinkish, with some white on the abdomen.

The nymphal stages differ very slightly from each other. The most noticeable differences are to be seen in the shape of the head and thorax. The colouration becomes darker and the spots and markings are more dense following each ecdysis.

Possibly, less evident is the gradual disappearance from the dorsal surface of all the abdominal segments, except 3 to 5, when the 3rd. instar is reached, of the chitinized portions of the integument,† or dorsal plates as they have been named Three of these dorsal plates—i.e., those on segments, 3, 4 and 5—bear the pores of odoriferous glands. As is usual, all these plates disappear when the adult stage is reached.

After the third moult has taken place, the rudiments of the hemielytra are to be seen, and, after the fourth moult they shew a marked increase in length, reaching beyond the anterior margin of the 4th. segment of the abdomen.

As regards the head, the main differences to be seen, are, the alteration in shape of the flattened lobes or juga which form the front part of the head, and the modification of the mucronate process in front of the eyes, which persists throughout the nymphal stages.

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†It has recently been suggested (4) that "sclerotised" be substituted for "chitinised," which is technically inaccurate, but since the designation "chitinised" is so generally understood it is thought that it is preferable to continue to employ it.

This mucronate process, when the adult stage is reached is reduced to a rounded or rotundato-angulate projection.

The lateral margins of the abdomen are serrate, with each "tooth" pointed and with short spines on the margins: In the adult stage the shape of the lateral margins of the abdomen is still serrate, but the "teeth" are considerably shorter and are rounded.

The adult insect of both sexes is entirely black or coppery black, but, owing to the presence of a whitish wax like substance, which is powdered over the whole body, except the wings, it appears greyish.

The membranous portion of the hemielytra is pale ochraceous, with an irregular dark brown shading, which is most pronounced along the veins.

Under laboratory conditions, the nymphs thrive equally well, whether placed singly in breeding cages, or whether placed together.

There is a tendency towards gregariousness when several nymphs or adults are housed together.

Both nymphs and adults have the curious habit of vibrating the antennae when disturbed.

The average duration of the instars is as follows:—

1st. instar.	10.10 days.
2nd. instar.	8.50 days.
3rd. instar.	9.75 days.
4th. instar.	15.30 days.
5th. instar	30.25 days.
Adult stage.	11.75 days.

These figures are based on the results of rearing eight individuals in the laboratory. The total life cycle from the the deposition of the ova to the death of the adults was 94.15 days.

The details of these figures are given in the table on page 436.

Conclusion.

The writer is indebted to Mr. W. E. China of the British Museum (Natural History), London, for his suggestions in connection with the subject of repugnational glands and to Che Kamardin bin Bahar for keeping the breeding records.

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Number.	1	2.	3.	4.	5.	6.	7.	8.
Date of oviposition -	8.10.28	8.10.28	8.10.28	8.10.28	8.10.28	8.10.28	8.10.28	8.10.28
Date of hatching -	15.10.28	15.10.28	15.10.28	15.10.28	18.10.28	18.10.28	18.10.28	18.10.28
Incubation period -	7 days	7 days	7 days	7 days	10 days	10 days	10 days	10 days
Date of first moult -	25.10.28	25.10.28	27.10.28	27.10.28	30.10.28	30.10.28	28.10.28	28.10.28
Period of first instar -	10 days	10 days	12 days	12 days	12 days	12 days	10 days	10 days
Date of second moult -	5.11.28	30.10.28	6.11.28	4.11.28	7.11.28	8.11.28	8.11.28	3.11.28
Period of second instar -	11 days	5 days	10 days	8 days	8 days	9 days	11 days	6 days
Date of third moult -	14.11.28	12.11.28	15.11.28	14.11.28	16.11.28	17.11.28	17.11.28	13.11.28
Period of third instar -	9 days	13 days	9 days	10 days	9 days	9 days	9 days	10 days
Date of fourth moult -	26.11.28	28.11.28	29.11.28	30.11.28	5.12.28	3.12.28	29.11.28	1.12.28
Period of fourth instar -	12 days	16 days	14 days	16 days	19 days	16 days	12 days	18 days
Date of fifth moult -	22.12.28	29.12.28	29.12.28	2. 1.29	10. 1.29	29.12.28	29.12.28	31.12.28
Period of fifth instar -	26 days	31 days	30 days	33 days	36 days	26 days	30 days	30 days
Date of death of adult -	31.12.28	11. 1.29	17. 1.29	10. 1.29	23. 1.29	17. 1.29	7. 1.29	4. 1.29
Life of adult -	9 days	13 days	19 days	8 days	13 days	19 days	9 days	4 days

A note on the ash of Nipah Juice and some experiments on preservation using Alcohol and Heat as sterilising agents and Copper Sulphate and Lime as preservatives.

BY

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Two samples of nipah juice have been examined for mineral ash constituents one sample of which was from cultivated palms and one sample from indigenous palms situated in the Kuala Selangor District.

The following results of analysis were obtained. Constituent in grams per 100 cc of juice.

	(a) Cultivated palms.	(b) Indigenous palms.
Nitrogen ...	0.036	0.047
Ash ...	0.630	0.575
On Ash.		
Potash (K_2O) ...	0.227	0.183
Phosphorus (P_2O_5) ...	0.025	0.024
Chlorides (Cl) ...	0.187	0.185
Sulphates (SO_3) ..	0.012	0.020
Iron & Alumina (Fe_2O_3 + Al_2O_3) ...	0.018	0.022
Calcium (CaO)	0.008	0.008
Magnesium (MgO) ...	0.005	0.013

PRESERVATION EXPERIMENTS.

It has been pointed out [1] that owing to the universal presence of yeasts in the local atmosphere nipah juice in the natural state rapidly undergoes inversion and fermentation and the experiments enumerated below were designed to ascertain the possibilities of arresting the reactions either in part or whole.

1. M. A. J. Vol. XV, December 1927, page 440.

It has been shewn previously that sulphuric acid [2] could be used for the purpose of greatly retarding fermentation though by its very nature it has an accelerating effect on inversion. It has been further shewn that alcohol[2] if present in sufficient quantity would stop all reactions.

As the result of a long series of observations it was realised that the inversion and fermentation which occurred in nipah juice on any given day was chiefly due to the action of yeast which had entered the collecting vessel two or three days previously rather than to that which entered on the day of collection and it therefore seemed probable that if this yeast from previous collections could be suitably poisoned each day a fairly sterile or at least uninverted unfermented juice would be obtained.

Gibbs shewed that the juice can be preserved with lime and this method was used in this Department to prepare a sample of sugar. [3]

It was decided to try the addition to the collecting vessels of sufficient alcohol to sterilise the yeast present, subsequently removing the majority of the alcohol before tapping started, thus operating with more or less sterile vessels. A further series of experiments was made in which the collecting vessels were completely sterilised by boiling.

Further it seemed possible that the juice might be made poisonous to yeast by the addition of a cheap toxic salt such as copper sulphate.

Experimental.

It is to be realised that whereas a small scale experiment of this nature may be quite successful, other factors (e.g. labour) may modify the results obtained in practice.

The following experiments therefore were carried out with the idea of indicating useful lines to be tried out on a practical scale.

(i) Collecting vessels flushed out thoroughly each day and in some cases twice a day with 95% alcohol, the alcohol being returned to its original container and used again daily until it became too dilute to have any effect.

2. M. A. J. Vol. XIV December, 1926.
3. M.A.J. March 1923. Philippine Journal of Science 1911 & 1912.

(ii) As above with the addition of one per cent. copper acetate to the alcohol used for flushing.

(iii) Collecting vessels sterilised by boiling.

(iv) Collecting vessels flushed with dilute solution of copper acetate.

(v) Copper sulphate added to the collecting vessels both solid and in solution.

(vi) Lime added to the collecting vessels.

The collecting vessels were glazed throughout, in the first five experiments glass bottles were used while in (vi) glazed earthenware pots were used, all previous experiments with lime having been made with porous vessels.

The results obtained are tabulated on pages 441 to 448 together with remarks on the individual experiments.

Summary.

The following general observations are offered on the results obtained.

(i) By a process of washing the collecting vessels with alcohol and collecting the juice every twenty four hours fermentation can be largely inhibited, being reduced to an approximate mean alcoholic content (apart from some of the added alcohol which remains in the bottle) of less than one per cent. as against 4.3 per cent. with untreated vessels. The ratio of invert sugar to total sugar can be reduced from 0.91 to 0.48 (circa 7% per cent.)

(ii) By heat sterilisation of the collecting vessels a similar inhibition of fermentation and reduction of inversion can be brought about.

(iii) By a combination of occasional heat sterilisation and alcohol flushing of the vessels fermentation and inversion is further reduced.

(iv) The retarding effect is very greatly increased by collection every twelve instead of every twenty four hours.

(v) Washing the bottles with a 1% solution of copper acetate combined with occasional sterilisation and twelve hour collection, has a very marked effect both on the prevention of inversion and fermentation.

(vi) When a solution containing about 0.6 grams or upwards of copper sulphate is added to the collecting vessel fermentation is almost completely inhibited, but the effect on inversion is not marked.

(vii) The maximum effect which can be obtained by a a three day sterilisation period combined with washing of the bottles with alcohol containing one per cent. of copper acetate and collecting every twelve hours, reduces the acidity to 0.055 per cent. as against 0.41 for unpreserved juice, the alcohol to about 0.2 as against 4.3 and the ratio of invert to total sugar to 0.155 as against 0.91 for untreated juice implying an invert sugar content of about 2.4 to a total of about 15.4 per cent.

(viii) By the addition of lime to the collecting vessels fermentation can be stopped and inversion retarded to a sufficient degree when lime is present to the extent of about four or five grams for a probable collection of 20 oz. of juice.

Experiment.	Days Alcohol in use.	Collection.	Particulars of preservation.	Sample.	Acidity per cent. as Acetic.	Invert Sugar per cent.	Total Sugar per cent.	Ratio Invert / Total.	Alcohol per cent. by Volume.	Alcohol equivalent as per cent by Volume.	Remarks.
A.			None. Juice straight from palms about 1 hour after cutting spathe.	Bulked from 12 palms	0.012	0.046	16.6	0.00277	nil.	11.0	This sample of juice fresh from the spathes taken more or less as a standard.
	1	Once daily	Alcohol treated	Individual spathe.	0.200	2.2	16.8	0.55	5.6 (0.0)	11.2	Examined A.M. about 27 hours from time of first flow of juice.
			,, ,,	,,	0.210	...	13.8		6.5 (0.8)	9.2	Alcohol equivalent calculated on sugar content only. Figures in brackets probable alcohol content due to fermentation balance of alcohol due to added preservative obtained by subtracting figures in brackets from total alcohol present.
			,, ,,	,,	0.185	11.2	13.4	0.837	10.5 (1.1)	8.9	
			,, ,,	,,	0.170	9.5	13.0	0.730	5.0 (1.5)	8.4	
	2	Once dialy	,, ,,	,,	0.110	4.0	15.8	0.254	0.5 (0.5)	10.5	Same remarks apply as to first set of samples above.
			,, ,,	,,	0.150	6.4	14.5	0.440	0.65 (.25)	9.6	
	16	Once daily	,, ,,	Bulk 2 spathes	0.240	11.0	11.5	0.957	2.8 (2.3)		The same remarks apply as to first set above. The alcohol used here has been in use for 16 days and has become diluted to such an extent that it has little effect on inversion and much less on yeast inhibitation than before.
			,, ,,	,,	0.300	9.4	10.5	0.892	3.2 (3.1)		
			,, ,,	,,	0.300	9.0	9.9	0.910	4.2 (3.4)		
			,, ,,	,,	0.440	10.1	10.7	0.945	5.0 (2.9)		

Experiment	Days Alcohol in use.	Collection	Particulars of preservation.	Sample.	Acidity per cent as Acetic.	Invert Sugar per cent.	Total sugar per cent.	Ratio Invert / Total.	Alcohol per cent by Volume.	Alcohol equivalent as per cent by Volume.	Remarks.
A.	1	Once daily	Control	Individual spathe.	0.330	6.6	7.2	0.916	6.7	11.2	Parallel samples to above.
			,,	,,	0.390	6.8	6.9	0.985	4.2	8.8	Examined same time after tapping.
			,,	,,		4.4	4.4	1.000	7.15	10.0	
	2	Once daily	,,	,,	0.350	9.7	11.5	0.843	2.9	10.5	Examined same time after tapping. In case of controls fresh samples collected daily. Figure in second column merely indicates the treated sample to which they correspond.
			,,	,,	0.370	9.3	10.3	0.902	3.6	10.3	
	16	Once daily	,,	Bulk 2 spathes.	0.330	7.5	7.6	0.986	4.85	9.9	
			,,	,,	0.400	6.9	7.1	0.975	4.65	9.35	
			,,	,,	0.500	5.5	5.5	1.000	4.25	9.05	
			,,	,,	0.525	5.3	5.4	0.980	5.95	9.6	
B.	1	Once daily	Alcohol treated	Bulk 20 spathes.	0.156	6.4	12.6	0.507	2.55 (1.6)	8.4	Fresh alcohol used. The same remarks apply as to first set above.
			,, ,,	,,	0.114	6.4	15.4	0.415	2.3 (nil)	10.1	
	14	Once daily	,, ,,	,,	0.198	10.1	13.8	0.745	7.1 (1.4)	9.15	Alcohol in use for 14 days still an effect on preservation, very little on inversion
			,, ,,	,,	0.240	11.1	15.3	0.721	3.3 (.3)	10.2	
	15	Once daily	,, ,,	,,	0.144	8.7	14.1	0.615	...	...	

Experiment.	Days Alcohol in use.	Collection.	Particulars of preservation.	Sample.	Acidity per cent as Acetic.	Invert Sugar per cent.	Total Sugar per cent.	Ratio Invert / Total.	Alcohol per cent by Volume.	Alcohol equivalent per cent by Volume.	Remarks.
B.	1	Once daily	Control	Bulk 20 spathes.	0.470	7.5	8.4	0.891	5.05	10.5	
	14	Once daily	,,	,,	0.365	11.1	11.7	0.950	2.5	10.3	
			,,	,,	0.420	10.0	10.6	0.945	2.4	9.4	
	15	Once daily	,,	,,	0.354	9.1	9.1	1.000	...	...	
C.	1	Once daily	Alcohol treated	Bulked 20 spathes.	0.210	6.9	13.8	0.500	6.5 (1.0)	9.2	Alcohol equivalent on sugar content only.
	4	,, ,,	,, ,,	,,	...	9.3	16.2	0.575	...	10.3	
	7	,, ,,	,, ,,	,,	...	11.4	14.8	0.770	...	9.8	
	1	,, ,,	Control	,,	0.490	6.9	10.1	0.682	3.5	10.2	
D.	1	Once daily	Bottle sterilised and alcohol treated.	,,	...	4.6	18.2	0.253	nil	12.1	Same batch of alcohol in use as in C. above.
	3	,, ,,	3 days after sterilising alcohol treated.	,,	...	9.5	17.2	0.552	nil	11.4	

Experiment.	Days Alcohol in use.	Collection.	Particulars of preservation.	Sample.	Acidity per cent. as Acetic.	Invert Sugar per cent.	Total Sugar per cent.	Ratio $\frac{\text{Invert}}{\text{Total.}}$	Alcohol per cent by Volume	Alcohol equivalent as per cent by Volume:	Remarks.
E.	1	Twice daily	Alcohol + 1% Cu. Acetate Bottles sterilised	Bulked 20 spathes.	0.042	2.0	14.8	0.135	5.5 (0.4)	9.8	Inversion and acidity gradually increase as time elapses from the first day. Bottles gradually being infected with active invertase.
	2	,, ,,	Alcohol +1% Cu. Acetate One day after sterilising.	,,	0.030	0.83	16.2	0.051	1.9 (nil)	10.7	Total sugar remarks more or less constant throughout.
	3	,, ,,	Alcohol + 1% Cu. Acetate Two days after sterilising.	,,	0.092	4.3	15.3	0.281	2.5 (nil)	10.2	Better results than with alcohol alone.
	4	,, ,,	Alcohol + 1% Cu. Acetate Three days after sterilising.	,,	0.150	6.9	14.9	0.463	1.5 (0.4)	9.85	Alcohol equivalent calculated on sugar content only. Probable alcohol due to fermentation given in brackets.
	4	,, ,,	do (second collection)	,,	0.250	4.1	15.1	0.272	1.3 (nil)	10.0	
	5	,, ,,	Alcohol + 1% Cu. Acetate Four days after sterilisiug.	,,	0.186	6.5	16.5	0.393	2.3 (nil)	10.9	
	6	,, ,,	Alcohol + 1% Cu. Aeetate Five days after sterilising.	,,	0.204	6.4	13.4	0.480	2.55 (1.8)	8.85	

Experiment.	Days Alcohol in use.	Collection.	Particulars of preservation.	Sample.	Acidity per cent as Acetic.	Invert Sugar per cent.	Total Sugar per cent.	Ratio Invert / Total.	Alcohol per cent by Volume.	Alcohol equivalent as per cent by Volume.	Remarks.
F.	1	Once daily	Alcohol Cu Acetate Bottles sterilised on first day	Bulked 20 spathes.	0.138	3.75	16.2	0.232	1.1 (nil)	10.7	Rather more invert sugar than twice daily collection.
	2	” ”	Alcohol Cu Acetate	”	0.190	5.9	15.1	0.390	2.3 (nil)	10.0	
	3	” ”	” ”	”	0.270	8.3	13.7	0.605	2.3 (1.2)	9.1	
	5	” ”	” ”	”	0.216	6.2	13.4	0.465	2.3 (1.4)	8.85	
G.	1	Twice daily	1% Cu. Acetate Bottles sterilised on first day.		0.180	3.9	15.0	0.260	0.45	10.4	
	2	” ”	” ”	”	0.150	3.1	16.7	0.186	nil	11.1	
	3	” ”	” ”	”	0.150	2.0	14.5	0.138	0.4	9.8	2nd collection.
	4	” ”	” ”	”	0.156	2.6	14.0	0.186	0.3	9.55	
	4	” ”	” ”	”	0.250	4.1	15.1	0.271	1.3	11.3	
	5	” ”	” ”	”	0.246	6.5	14.5	0.448	2.1	11.6	
	6	” ”	” ”	”	0.174	4.3	12.3	0.350	1.32	9.45	

Experiment.	Day Alcohol in use.	Collection	Particulars of preservation.	Sample.	Acidity per cent as Acetic.	Invert Sugar per cent.	Total Sugar per cent.	Ratio Invert / Total.	Alcohol per cent by Volume.	Alcohol equivalent as per cent by Volume.	Remarks.
H.		Once daily	Control on all above E, F & G. Bottles sterilised first day.	Bulked 20 spathes.	0.450	8.4	11.8	0.713	2.5	10.3	
		,, ,,	,, ,,	,,	0.400	8.0	9.2	0.865	4.5	10.6	
		,, ,,	,, ,,	,,	0.400	8.0	9.3	0.860	4.4	10.6	
		,, ,,	,, ,,	,,	0.420	7.5	8.0	0.940	4.5	9.8	
I.		Once daily	.5 gms. Cu SO$_4$ 5H$_2$O added to bottle	Single spathe.	...	11.0	11.0	1.00	..	?	Samples examined after keeping for 24 days after tapping
		,, ,,	1.5 gms ,, ,,	,,	...	17.2	17.8	0.97	...	11.8	
		,, ,,	2.0 gms ,, ,,	,,	...	15.1	15.2	0.99	...	10.1	
J.		Once daily	0.5 gms Cu So$_4$ 5H$_2$O	Bulked 6 spathes.	...	11.0	13.8	0.80	2.1	11.2	Ground copper sulphate added in the quantities stated. to the collecting vessels.
		,, ,,	0.75 ,, ,,	,,	...	13.3	13.9	0.96	2.1	11.3	
		,, ,,	1.00 ,, ,,	,,	...	6.9	13.6	0.51	1.2	10.2	
		,, ,,	1.25 ,, ,,	,,	...	9.2	14.0	0.66	1.0	10.3	
		,, ,,	0.00 ,, Control	,,	...	10.4	10.4	1.00	3.3	10.2	

Experiment.	Days Alcohol in use.	Collection.	Particulars of preservation.	Sample.	Acidity per cent as Acetic.	Invert Sugar per cent.	Total Sugar per cent.	Ratio Invert / Total.	Alcohol per cent by Volume.	Alcohol equivalent as per cent by Volume.	Remarks.
K.		Once daily.	.5 gms. Cu SO_4 same	Bulked 6 spathes.	...	13.1	13.3	0.98	2.5	11.2	Very little further fermentation has occurred in the treated samples.
		,, ,,	.75 ,, ,, samples	,,	...	13.8	13.9	0.99	2.1	11.3	
		,, ,,	1.10 as J	,,	..	9.3	13.6	0.68	1.2	10.2	
		,, ,,	1.25 ,, ,, examined 16 hours later.	,,	..	11.5	14.0	0.82	1.0	10.3	
		,, ,,	0.00 ,, Control.	,,	...	7.7	7.7	1.00	5.1	10.2	
L.		Twice daily	0.00 gms. Control.	,,	...	10.6	10.6	1.00	4.5	11.5	It is probable that the preliminary fermentation which occurs is due to the formation at first of two layers copper sulphate going into solution slowly from the bottom and fermentation occurring in the upper layer before the copper sulphate has become homogenously distributed.
		,,	0.5 ,, Cu SO_4 5 H_2O	,,	...	9.8	13.8	0.71	1.4	10.5	
		,,	0.75 ,, ,,	,,	...	7.6	14.8	0.51	0.8	10.6	
		,,	1.00 ,, ,,	,,	...	6.2	14.8	0.42	0.6	10.4	
		,,	1.25 ,, ,,	,,	...	2.4	16.2	0.15	0.3	11.0	

Experiment.	Days Alcohol in use.	Collection.	Particulars of preservation.	Sample.	Acidity per cent, as Acetic	Invert Sugar per cent.	Total Sugar per cent.	Ratio Invert / Total.	Alcohol per cent by Volume.	Alcohol equivalent as per cent by Volume.	Remarks.
		Once daily.	.6 gms. copper sulphate as solution.	Bulked 6 spathes.	...	7.5	15.9	.472	nil	10.5	
		,, ,,		,,	...	8.4	15.2	.552	nil	10.1	
		,, ,,		,,	...	6.7	14.5	.463	nil	9.6	
M.		,, ,,		,,	...	9.3	14.8	.628	1	9.9	Fermentation almost completely arrested. Effect on inversion insufficient.
		,, ,,	.9 ,, ,,	,,	...	11.2	16.0	.700	nil	10.6	
		,, ,,		,,	...	8.5	13.7	.621	3	9.4	
		,, ,,		,,	...	7.1	15.8	.450	nil	10.5	
		,, ,,			...	8.9	16.2	.550	nil	10.7	
		Once daily.	Lime 1 gm. approx.	Bulked 6 spathes	0.25	6.0	10.0	.600	...	..	Some fermentation occurring.
		,, ,,	,, ,, ,,	,,	0.20	4.5	11.1	.405	...	...	Some fermentation occurring.
					Alkalinity as Ca $(HO)_2$						
		,, ,,	Lime 2 gms. approx.	,,	0.148	1.6	13.9	.115	...	8.8	Good state of preservation.
		,, ,,	,, 4 ,,	,,	0.285	1.5	14.1	.106	...	8.9	Good state of preservation.
		,, ,,	,, 6 ,,	,,	0.370	1.5	14.0	.107	...	8.8	Good state of preservation.
		,, ,,	,, 1 ,,	,,	0.101	2.7	12.6	.214	...	8.0	Good state of preservation. Small yield.
		,, ,,	,, 2 ,,	,,	0.121	1.7	13.8	.123	...	8.8	Good state of preservation. Small yield.
		,, ,,	,, 1 ,,	,,	0.090	2.3	13.5	.171	...	8.6	Good state of preservation. Small yield.
N.		,, ,,	,, 1 ,,	,,	0.121	2.2	13.7	.161	...	8.8	Good state of preservation. Small yield
		,, ,,	,, 2 ,,	,,	0.152	1.9	15.2	.125	...	9.7	Fair state of preservation. Large yield.
		,, ,,	,, 2 ,,	,,	0.178	1.9	14.8	.128	...	9.4	Fair state of preservation. Large yield.
		,, ,,	,, 1 ,,	,,		Fermenting					Large yield 1 gm. insufficient to arrest fermentation and inversion.
		,, ,,	,, 1 ,,	,,		,,					
		,, ,,	,, 4 ,,	,,	0.201	2.7	14.5	.186	...	9.2	Good state of preservation.
		,, ,,	,, 4 ,,	,,	.212	2.9	14.0	.203	...	8.9	Good state of preservation.
		,, ,,	,, 4 ,,	,,	.228	4.8	13.8	.348	...	8.8	Examined in the Laboratory. } 36 hours after collection.
		,, ,,	,, 4 ,,	,,	.234	3.8	16.0	.238	...	10.2	Good state of preservation. } 10 hours after collection.

A Preliminary Note on the Sugar Palm.

By

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and

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The sugar palm, *Arenga saccharifera* Labill. occurs in "kampong" land throughout the Malay Peninsula. It is commonly planted by Malays for domestic use. Ridley records this species as apparently wild in Province Wellesley but he notes that the stems of these palms were more slender and less provided with fibre than in the typical plant (*Flora Mal. Pen.* Vol. V, page 19). The cultivated palm is known to the Malays as "Kabong" whereas the wild form is called "Enau." A distinct species *A. Westerhouti* Griff. "langkap," (Malay) is commonly met with on the hills but is of little or no economic importance.

Description and Uses.—The sugar palm is characterised by its large ascending, pinnate leaves and stout stem, covered with black fibre, reaching a height of 30 feet. The stem is usually solitary. The large pendulose inflorescence, 3 to 4 feet long, is produced from the axil of the leaves. The green fruits are produced in great abundance on the female inflorescence and become yellow in colour as they mature. Each fruit contains several black seeds about 1 inch long.

Various parts of the palm are used by Malays for a variety of purposes. The black horsehair—like fibre, produced at the base of the petioles, is used for making rope and twine, and is specially valuable to fishermen owing to its resistant qualities to the action of salt water.

Sugar and molasses (gula Malacca) are obtained from the flower shoots.

The interior of the immature fruits are commonly made into a sweetmeat by boiling with sugar. Several other uses are made of the palm but these are the most important.

Cultivation at the Government Plantation, Serdang.

The following information has been obtained from a small block of palms ($9\frac{1}{2}$ acres) planted on low-lying, flat land composed of a stiff loam at the Government Plantation, Serdang.

Seedling palms were planted during October, 1922, at a planting distance of 20 feet by 20 feet, allowing 108 palms to the acre. This distance has proved to be rather too close and a planting distance of 25 feet by 25 feet, triangular planting is recommended, especially on fertile land.

The first flower spathes were observed in March, 1928. i.e., $5\frac{1}{2}$ years after planting in the field; the palms have flowered more freely during 1929, though so far only a small proportion have reached maturity i.e., the flowering stage.

Collection of Juice at Serdang.

The approximate period between the opening of the spathe to the commencement of tapping is 70 days. Male and female spathes, and spathes with male and abortive female flowers occur and have been tapped.

The juice is mainly obtained from the male spathes although certain of these failed to yield any sap. The female spathes give very small quantities of sap only. The spathes with male and abortive female flowers have been found to yield practically no sap. After the commencement of tapping the spathes, the juice flows for a period of $1\frac{1}{2}$ to 2 months.

Prior to the commencement of tapping the spathe selected is beaten with a wooden mallet for a short time each day. This operation continues for two weeks, in order to stimulate a greater flow of sap into the peduncle.

When the flowers in the spathe open, the stem is severed at the base of the inflorescence and the cut end inserted into an earthenware pot as used by toddy collectors. The exudation of sap during the first and second day is slight but on the third day a large flow occurs. A thin slice is removed from the end of the stalk twice daily during the period that the sap continues to flow. This lasts, as has already been stated for 6 to 8 weeks.

A writer in the *Agricultural Bulletin, F.M.S.* Vol. I, page 191, (1912) describes the operation of tapping the palm as employed by Malays as follows:—

"On the appearance of the first spadix, the trunk and spadix are beaten twice a day until the flowers open, these are cut away and the liquid is led by means of fibre cords to receptacles placed on the ground to receive it. The beatings continue twice daily until the spadix is exhausted. If the flow stops or decreases, the stem of the spadix is again cut a little lower down.

The liquid obtained is usually collected in bamboos, these are previously smoked in order to arrest fermentation which takes place very quickly if the sap is exposed to the atmosphere for any time or is allowed to come in contact with any nitrogenous matter. It is collected every six hours and poured into iron dishes (Kualis), and heated until evaporation causes it to become a thick brownish, bubbling syrup, which solidifies on cooling. It is then poured into a series of wooden moulds (Achu-Gula), and allowed to cool. The sugar is then ready for consumption and is sold in the kampong shops at prices averaging from 9 to 12 cents per kati."

The flowering habits of the sugar palm are irregular and so far have not been examined critically at Serdang. Barrett states (*Philippine Agricultural Review*, Vol. VII, page 216) that of certain palms under observation in the Philippine Islands, about 90 per cent. were monoecious i.e., both male and female clusters were produced on the same palm. The remaining palms produced male spathes and abortive female flowers.

Preliminary tapping has so far only been undertaken but the following yields of sap are recorded from individual palms :—

Yield of Sap from Palms

Palm number.	Spathes tapped.	No. of days tapped.	Quantity of sap in gallons.
248	Three male flowers	170	162
156	One male flower	34	3½
49	Two male flowers	29	4¼
103	One male flower	12	1
176	One male flower	12½	4
D	Two male flowers	29	25¾

K	One male flower	32	24
A	One male flower	14	9
B	One male flower	36¾	4¾
F	One male flower	50	71¼
L	One female flower	8	1/6
305	One female flower	4	1/12
49	One female flower	9	1½
F	One flower, male and female in one bunch.	23	¾

It will be seen that a high yield of sap occurs but considerable variability in yield from individual spathes is recorded. The female spathes, so far, have yielded comparatively no sap.

Two samples of juice from these palms, preserved with lime, were examined at the Department of Agriculture, Kuala Lumpur. The juice apart from a slight amount of lime in suspension was almost water clear and of a very pale yellow colour.

The following data was obtained:—

22.10.29.

Density compared with water at 84°F 1.0315 corresponding to approximate sugar content of 7.9.

CONSTITUENT PER 100 cc.

Saccharose	...	7.10 gm.
Invert Sugar	...	0.15 ,,
Non Sugars	...	0.29 ,,
Nitrogen	...	0.005 ,,
Ash	...	0.021 ,,

29.10.29.

Density compared with water at 84°F 1.0200 corresponding to an approximate sugar content of 5.1.

CONSTITUENT PER 100 cc.

Saccharose	...	4.89 gm.
Invert Sugar	...	0.11 ,,
Non Sugars	...	0.21 ,,
Nitrogen	...	0.005 ,,
Ash	...	0.018 ,,

The ratio of Invert sugar to Saccharose is low, and the yield obtainable per palm is high, this seems to be counter-balanced to some extent by the sugar content which necessitates a large amount of evaporation compared with the sap of nipah or coconut.

Two litres of juice was evaporated under reduced pressure at 40—45°C. The sucrose crystallised out excellently and after centrifuging a good pale yellow sugar was obtained.

It is probable that it is for the reason of its good crystallising properties that it is so highly esteemed by Malays for making "gula Malacca". This latter has been prepared; one gallon of juice yielding about half a pound of sugar, corresponding to a total sugar content of five per cent.

Received for Publication November 25th, 1929.

Laterite.

By J. B. Scrivenor.
Director of Geological Surveys.

During the last few months I have been asked so often by officers who are interested in soils to tell them briefly what "laterite" is that I decided to write a paper on the subject in reply to the query, in the hope that it will be of interest and some value to several officers of technical departments in Malaya.

In the first place let us deal with the origin of the word. It was first used in 1807 by F. Buchanan in "A Journey from Madras through Mysore, Canara and Malabar." In dealing with the iron-ore seen during his journey he wrote:—"In all the hills of the country the ore is found forming beds, veins, or detached masses in the stratum of indurated clay, that is to be afterwards described, and of which the greater part of the hills of Malabar consists............What I have called indurated clay..............is one of the most valuable materials for building. It is diffused in immense masses, without any appearance of stratification, and is placed over the granite which forms the basis of Malayala. It is full of cavities and pores and contains a very large quantity of iron in the form of red and yellow ochres. In the mass, while excluded from the air, it is so soft, that any iron instrument readily cuts it, and is dug up in square masses with a pickaxe, and immediately cut into the shape wanted with a trowel, or large knife. It very soon after becomes as hard as a brick, and resists the air and water much better than any bricks I have seen in India ....As it is usually cut into the form of bricks for building, in several of the native dialects it is called the brick stone (Itica cullu)..............The most proper English name would be laterite, from lateritis, the appellation that may be given to it in science."

The Latin root from which the word is derived is "latus," a brick or tile. Note that in the passage above it is clear that Buchanan meant the term to be applied to the "indurated clay" and not to the iron-ore. He says it contains a very large quantity of iron in the form of red and yellow ochres and describes how it hardens on exposure and is used for building in the form of bricks.

What Buchanan was describing is a common weathering product of rocks, found in most tropical countries. People who had seen the red and yellow indurated clay in India carried the word to other countries and applied it to red and yellow weathering product they saw there Thus any red soil or soil mottled red and yellow came to be called laterite although it might not be possible to cut it into bricks, which was the real test of similarity of Buchanan's laterite, and, worse still, the name came to be applied to hard masses of iron-ore in red or mottled soils, especially by engineers, who in Malaya used to call them, and possibly still call them, "No. 1 laterite" because they form the best laterite road-metal. So here were two deviations already from Buchanan's original intention regarding the use of the word.

In India the use of the word spread, but it was not until 1903 that general interest in the chemical composition of laterite was aroused. In the Geological Magazine for that year Sir Thomas Holland had a paper on the "Constitution, Origin, and Dehydration of Laterite" in which he said that if the term "clay" is restricted to substances having a basis of hydrous silicate of alumina, it is wrong to call laterite "ferruginous clay" because in laterite the alumina exists, as in bauxite, in the form of hydrous oxides (op. cit. pp. 68, 69). He also said (p. 61) "Professor Bauer has now shown that laterite reproduces "the essential characters of bauxite."

In the same volume of the Geological Magazine H. and F. J. Warth published analyses of Indian laterites (pp. 154-159). On p. 159 they wrote:—"Laterite is bauxite in various degrees of purity, from the richest Wocheinite down to such specimens in "which the free alumina has entirely disappeared. It will make this paper easier to follow if I add that bauxite is an amorphous hydrate (hydrous oxide) of aluminium generally having the composition $Al_2O_3 . 2H_2O$, while there are two other, but crystalline hydrates of aluminium, disapore ($Al_2O_3 . H_2O$), and gibbsite ($Al_2O_3 . 3H_2O$). Wocheinite is a very pure bauxite, grey, with very little iron oxide. "Free alumina" here means Al_2O_3 not combined with silicic acid or any other acid radicle, but it may be combined with water.

The great majority of people who had come to use the term "laterite" as a common word, engineers, agriculturists

and others probably never heard of those analyses at all; but among geologists, those, and other analyses, gave rise to an unfortunate idea that all laterite contained a high percentage of aluminium hydrate, and that if a decomposition product did not contain a high percentage of aluminum hydrate it should not be called laterite. This latter dictum was queried and a controversy on the subject arose, which lasted for at least two years and was summarised by Dr. L. L. Fermor in 1911 (Geological Magazine pp. 454, 507 and 559), but unfortunately this author, in an endeavour to clarify the position, suggested the use of two new terms, "lateritoid" and "lateritite" which, if adopted, would have made matters worse than ever.

In spite of efforts to prevent it the idea spread among geologists that laterite was essentially a weathering product containing a high percentage of aluminium hydrate; but in 1923, Dr. C. S. Fox published a memoir on "The Bauxite and Aluminous Laterite Occurences of India" (Memoirs of the Geological Survey of India, Vol. xlix, part 1). In this work Dr. Fox illuminates the position regarding Indian laterite. If it contains enough aluminium hydrate to be used as aluminium-ore it should, he says, be called bauxite (this had been previously suggested by Dr. Fermor), and his use of the term "aluminous laterite" shows that he regards that as a special kind of laterite, not typical laterite. On p. 5 he writes:—"Practically all the bauxites or aluminous laterites occur associated with primary laterite—those which have been formed from various types of rock *in situ*. These bauxite segregations constitute an exceedingly small proportion of the primary laterite of the country. A very small percentage of the secondary laterites have enrichments of aluminous laterite suitable for use as bauxite." So the laterite rich in aluminium hydrate which caused so much interest in 1903 is described in 1925 as "an exceedingly small proportion" of primary laterite and "a very small percentage" of secondary (detrital) laterite. If that is so, and I have no reason to suppose that Dr. Fox is wrong, it is impossible to take richness in aluminium hydrate as the leading characteristic of laterite and it appears to me that popularisation on the one hand and enthusiasm over a few analyses on the other have destroyed the value of "laterite" as a scientific term; while those geologists who insisted on a high percentage of aluminium hydrate as the test of laterite are as far from Buchanan's intention as to the use of the word which he originated, as are engineers who call masses of iron oxide in the soil "No. 1 laterite."

In Malaya we have some laterite that fits Buchanan's definition exactly, in Malacca Territory,* where schists, and granitic rocks weather to a red and yellow mottled mass which, in the case of the schists and perhaps to a small extent of the granite, can be quarried and used as Buchanan describes. But it is certain that the bulk of the alumina is combined with silica, and is not present as free aluminium hydrate. Superficially it closely resembles specimens I have seen of Indian laterite. An analysis by Mr. J. C. Shenton of this Malacca laterite, over schists, is as follows:—

Silica ...	23.60%
Titanium dioxide ...	.86%
Ferric oxide ...	37.94%
Alumina ...	21.60%
Manganese ...	trace
Lime ...	1.20%
Zirconia ...	trace
Magnesia ...	.45
Sulphuric Anhydride ...	3.36
Potash ...	.34
Soda ...	.37
Water and loss on ignition ...	11.20
	100.92

Among geologists I think it is generally assumed now that if "laterite" is mentioned, something containing aluminium hydrate is referred to—quite wrongly—but others may refer to a red or yellow soil or to an iron-oxide, and I think that for scientific work the term would be much better dropped.

But from under all this confusion there is one definite piece of information that has emerged, and that is that under certain conditions silicate-rocks produce aluminium hydrate as a final weathering product instead of hydrous aluminium silicates. What those conditions are is not yet certain. Some say tropical conditions are necessary but that is not proved; or that alternation of wet and dry seasons is required, but that is not proved either. The formation of aluminium hydrate, however, is more marked in rocks with a low, than with a high silica percentage. The change that takes place is a step

*Newbold, in "British Settlements in Malacca (1839) quotes Dr. Ward as saying that the Malacca laterite is exactly the same as the rock on the Malabar Coast described by Buchanan as "laterite."

beyond the formation of the hydrous silicate, which is broken down, silica being carried off in solution, and hydrate remaining.

In Malaya, in Indo-China, and in the Netherlands Indies the change in "acid," granitic rocks, which have a high percentage of silica, does not go beyond the formation of hydrous silicate of alumina, except perhaps for a small proportion hard to prove, and therefore the soil is clayey owing to the presence of kaolinite and perhaps halloysite. In less acid or "basic" rocks, on the other hand, when weathered, there is an appreciable amount of aluminium hydrate; but it is curious that the only occurrence of hydrate in large percentage in Malaya is as nodules of a white or creamy colour above schists e.g. at Redhills, Kinta, Rawang, and in Malacca—which are of no economic importance. In Kuantan is situated the only large area where basic rocks form the soil. This is about 30 square miles of soil derived from dolerite, north and north-west of the township of Kuantan. The soil resembles the volcanic soils of Java, being derived from a similar rock.

But what particularly concerns us here is whether laterite in any sense of the word, is of importance in agriculture and forestry. Rocks supply three important plant-foods, calcium carbonate ($CaCO_3$), potash (K_2O), and phosphorus pentoxide (P_2O_5). Iron and magnesia are of minor importance, and as far as I am aware, alumina is of no importance as a plant-food.

First consider the red, yellow, and mottled soils formed over "acid rocks." Here we are dealing really with ordinary soils and we expect to get a little $CaCO_3$ only, a little P_2O_5, but more K_2O. The hydrous silicate of alumina derived from felspar makes the soils rather clayey unless grains of quartz are abundant.

The same is true for the laterite in Malacca and generally for soils over schists, as for soils over acid rocks.

The masses of iron ore referred to as "laterite" by engineers we need not consider.

Is bauxite, or an aluminous laterite, a good soil? Bauxite is essentially Al_2O_3 H_2O with Fe_2O_3, SiO_2, P_2O_5, CaO, and MgO as common impurities (Dana. System of Mineralogy p. 251).

The analyses of H. and F. J. Warth of certain Indian laterites, which can be described as bauxites and aluminous laterites, show as the main constituents Al_2O_3, Fe_2O_3, H_2O, SiO_2, TiO_2. CaO and MgO are unimportant; F_2O_5 and K_2O are not mentioned.

If the volcanic soils of Java and Kuantan are considered to be laterite on the ground that they contain much aluminium hydrate, then is their richness as soils due to that hydrate? Chemically it is not; the rocks from which the soils are derived yield more $CaCO_3$ and P_2O_5 than acid rocks, and are therefore richer.

As a source of plant foods, therefore, laterite is not of special importance; but mechanically it may be of considerable importance in soils. It may be beneficial or the reverse.

In the case of a weathering product rich in aluminium hydrate the proportion of "clay" is small, or it may be absent altogether. The result is that such soils are earthy, open and porous. In the case of Kuantan dolerite soil this may be of importance in allowing the free circulation of plant foods and perhaps in aeration and growth of roots, but such soils in Malay generally contain a fair amount of particles small enough to be classed as clay in mechanical analysis. But at the same time they are distinctly friable.

On the other hand soils are frequently so impregnated with iron-oxide that their porosity is reduced or destroyed altogether, which must have a bad effect on vegetation. In the latter case the so-called "laterite" is nothing more than the "iron-pans" of Europe, which are often a source of trouble to agriculturists.

In conclusion I would suggest that the word laterite be used as little as possible. In Malaya we have typical laterite as defined by Buchanan, but it is only weathered rock impregnated with iron-oxide, and contains a large amount of hydrous silicate of alumina or "clay." On the other hand the word is applied popularly to masses of iron-oxide and red decomposition products which are simply ordinary soils coloured by Fe_2O_3. The formation of large quantities of aluminium hydrate may be of importance mechanically in a soil, but it is unnecessary, and incorrect, to associate that with Buchanan's word "laterite."

ABSTRACT OF METEOROLOGICAL

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
Perak—													
Taiping ...	81.8	86.5	77.4	90.5	72.5	72.5	93	12, 28	70	12th	85	18th	74
Kuala Kangsar ...	78.1	87.7	77.0	90.8	70.2	..	93	1st	65	Sev	87	17th	74
Batu Gajah ...	79.6	88.5	76.8	91.1	71.9	..	94	14th	68	22nd	86	25th	77
Gopeng ...	81.0	87.7	77.1	90.2	72.0	..	98	14th	68	22nd	86	25th	76
Ipoh ...	80.1	88.9	76.9	92.2	71.1	..	95	18th	67	28rd	88	25th	78
Kampar ...	79.2	88.0	76.6	90.5	71.5	..	92	Sev	68	22nd	85	2nd	78
Teluk Anson ...	78.8	84.6	76.8	89.3	77.8	..	92	15, 22	75	12.31	85	28th	80
Tapah ...	81.0	87.8	76.1	90.2	70.5	..	98	15th	66	28rd	86	17th	74
Parit Buntar ...	82.1	87.0	76.2	88.4	71.6	..	91	1st	65	24th	85	4th	75
Bagan Serai ...	80.8	87.5	77.2	89.9	72.1	..	98	28rd	67	28rd	85	18th	75
Selama ...	79.7	90.8	77.8	92.0	71.7	..	94	Sev	64	23rd	89	Sev	77
Lenggong ...	78.8	89.2	76.2	90.8	69.3	..	98	Sev	63	28rd	87	25th	76
Tanjong Malim ...	79.8	87.9	74.9	91.1	70.8	..	94	14th	66	21st	88	Sev	78
Grik ...	76.8	86.9	75.8	89.7	70.0	..	93	18th	64	22, 28	85	4,19	76
Klian Intan ..	75.7	84.4	71.8	88.0	67.0	..	91	18th	64	23, 29	85	Sev	72
Kroh ...	76.2	83.6	71.7	85.6	68.8	..	90	13, 14	68	24th	82	2nd	71
Tanjong Rambutan ...	81.9	90.3	78.1	92.9	71.7	..	95	16th	70	Sev	90	Sev	78
Sitiawan ...	81.1	85.7	76.0	86.2	72.2	..	90	Sev	68	23rd	85	24th	75
Selangor—													
Kuala Lumpur Rly. Hill ...	80.0	85.6	75.9	90.8	71.8	68.8	94	Sev	68	21, 22	87	24th	74
K.L. Inst. for Med. Research ...	80.6	86.9	77.1	90.8	72.0	..	94	14th	68	22nd	88	Sev	74
Bukit Jeram ...	80.9	85.9	76.0	88.8	71.9	71.1	91	18th	69	21, 22	85	17th	74
Kajang ...	81.9	89.9	76.1	90.2	70.7	..	94	14, 15	67	22nd	87	Sev	72
Kuala Selangor ...	81.2	84.7	78.1	86.2	72.9	..	89	1st	71	19, 21	85	Sev	75
Serendah ...	80.2	85.6	76.2	90.2	71.7	..	94	1, 15	69	Sev	86	18th	74
Kuala Kubu ...	81.1	85.7	75.0	90.5	70.8	..	94	14th	66	22nd	88	28th	78
Telok Datoh ...	..	..	..	88.7	71.7	..	92	14th	70	Sev	86	27th	74
Negri Sembilan—													
Seremban ...	82.0	86.0	77.0	89.6	71.8	..	98	10, 18	70	19th	87	26.28	78
Kuala Pilah ...	..	..	.	87.1	69.5	..	91	14th	67	Sev	84	2.4	72
Tampin ...	82.6	84.6	75.6	89.8	67.5	..	92	Sev	66	Sev	87	25th	69
Port Dickson ...	82.8	85.2	77.8	87.0	74.5	..	92	8th	78	27th	85	18, 17	76
Jelebu ...	79.1	86.2	74.1	88.0	70.2	..	91	14th	69	Sev	84	31st	72
Pahang—													
Kuala Lipis ...	77.4	89.8	76.1	91.4	71.1	..	93	15, 18	68	23rd	89	22nd	73
Raub ...	77.8	84.0	74.6	85.8	70.0	68.8	90	9th	58	23rd	81	4th	73
Bentong ...	77.7	86.8	75.3	90.5	71.6	..	94	10, 14	68	22nd	85	4th	76
Pekan ...	79.	82.8	76.1	85.3	72.3	..	87	Sev	69	28th	82	2nd	74
Kuantan ...	79.5	83.0	76.7	85.7	71.8	..	88	Sev	69	22nd	81	4th	75
Temerloh ..	77.6	86.0	75.4	87.6	70.9	70.0	92	14, 30	68	22, 23	80	4th	74
Hill Stations—													
Cameron's H'lands (Tanah Rata)	65.5	68.8	60.1	71.5	55.6	50.4	74	9,18	46	21st	68	1st	61
Cameron's H'lands (Bt. Mentigi.)	64.7	66.7	..	71.2	58.9	55.4	75	Sev	55	6, 23	67	Sev	60
Fraser's Hill ...	68.9	67.7	63.2	69.9	60.6	59.3	76	10th	58	23rd	65	Sev	63
Maxwell's Hill ...	70.0	70.6	67.1	78.6	64.4	..	77	1st	63	Sev	71	22nd	66

RAINFALL

Perak. —	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—
Kuala Kurau ..	2.21	56.1	32.5	4th	6	Bagan Datoh ..	6.59	167.4	44.6	6th	11	Sabak Bernam.
The Cottage ..	6 39	162.3	87.8	12th	14	Sungkai ..	10.27	261.0	88.0	12th	14	Dist. Hosp., K.L.
								..				Genl. Hosp. K.L.
												Klang ..
												P. Swettenham

MALAYAN METEORO[L...]

ABSTRACT OF METEOROLOGICAL O[...]

Air Temperature in degrees Fahrenheit.

STATION.	Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
Perak—													
Taiping ...	81.0	80.8	76.8	88.8	72.5	72.5	92	1st	71	9th	88	18th	74
Kuala Kangsar ...	78.8	83.9	75.9	88.9	72.9	..	93	2nd	71	25th	82	Sev	74
Batu Gajah ...	79.0	88.7	75.4	89.0	72.8	..	93	3rd	70	1st	78	14th	74
Gopeng ...	80.6	88.4	75.5	88.2	72.8	..	91	2nd	70	19th	79	14th	74
Ipoh ...	79.6	84.8	75.4	90.1	72.2	..	94	22nd	70	20th	81	16th	74
Kampar ...	78.5	86.0	75.5	89.4	71.9	..	92	5th	69	25th	86	12,18	75
Teluk Anson ...	79.0	88.7	76.7	87.8	77.8	..	91	20, 22	73	2nd	80	14th	80
Tapah ...	80.4	84.1	75.2	89.0	71.7	..	93	22nd	69	29th	82	18, 14	74
Parit Buntar ...	82.7	83.0	75.9	87.5	72.9	..	90	Sev	71	Sev	82	12th	75
Bagan Serai ...	80.8	84.4	76.4	88.5	73.4	..	92	28th	72	Sev	88	11, 14	75
Selama ...	80.3	86.0	76.2	89.8	73.4	..	94	1, 20	70	1st	82	11, 12	77
Lenggong ...	78.9	86.8	75.1	88.6	71.5	..	93	6, 21	69	Sev	80	25th	78
Tanjong Malim ...	79.1	82.9	74.0	89.1	70.9	..	93	20th	68	4th	78	18, 14	72
Grik ...	77.4	83.7	75.0	88.6	72.4	..	93	1st	70	Sev	79	12th	73
Klian Intan ...	76.4	78.8	70.2	87.3	69.5	..	91	3rd	67	28th	84	11th	71
Kroh ...	77.3	79.4	71.7	84.2	69.6	..	88	5, 14	68	Sev	81	Sev	71
Tanjong Rambutan ...	81.2	88.4	77.5	92.2	71.7	..	95	22nd	69	18th	89	11th	73
Sitiawan ..	79.8	84.0	75.4	87.1	73.4	..	90	18, 20	72	Sev	81	14th	75
Selangor—													
Kuala Lumpur Rly. Hill ...	79.7	83.9	75.7	89.3	72.3	70.9	93	Sev	71	Sev	78	18, 14	74
K.L. Inst. for Med. Research ...	79.6	84.1	76.1	89.0	73.1	..	92	Sev	71	1st	78	13, 14	75
Bukit Jeram ...	80.0	84.2	75.8	87.2	72.2	71.9	89	Sev	71	Sev	79	14th	74
Kajang ...	81.8	88.6	75.6	88.7	71.6	..	92	Sev	70	Sev	80	14th	73
Kuala Selangor ...	80.4	83.2	73.8	84.8	73.1	..	88	3rd	72	Sev	79	14th	75
Serendah ...	80.1	81.9	75.2	88.8	71.7	..	92	4, 22	69	15th	81	14th	73
Kuala Kubu ...	80.2	82.2	74.6	88.4	71.4	..	92	Sev	70	Sev	78	14th	73
Telok Datoh ...	..	..	..	87.4	72.6	..	91	26th	71	27, 28	79	13th	74
Negri Sembilan—													
Seremban ...	81.3	85.5	76.8	89.4	71.4	..	91	Sev	70	Sev	87	13, 15	78
Kuala Pilah ...	..	..	..	88.3	70.3	..	96	9th	68	26, 28	83	19th	72
Tampin ...	81.0	84.4	75.7	87.8	63.8	..	98	23rd	62	Sev	80	14th	68
Port Dickson ...	80.5	88.8	77.3	85.2	74.6	..	89	30th	73	17th	79	18th	76
Jelebu ...	78.9	84.7	74.2	87.2	70.5	..	90	Sev	68	28th	80	14, 16	72
Pahang—													
Kuala Lipis ...	77.1	89.5	76.3	91.0	71.7	..	93	19th	70	Sev	88	13, 14	74
Raub ...	77.7	83.1	74.6	86.2	71.2	70.0	90	17, 21	70	Sev	75	13th	73
Bentong ...	78.8	85.0	75.2	90.5	72.2	..	94	17th	70	Sev	87	27th	74
Pekan ...	79.9	82.1	75.4	86.1	72.7	..	89	Sev	71	9th	79	26th	75
Kuantan ...	79.5	82.4	76.4	85.7	72.8	..	90	21st	71	1, 18	77	13, 14	75
Temerloh ...	77.6	84.5	75.4	87.1	72.5	71.8	92	20, 22	70	27th	76	13th	74
Hill Stations—													
Cameron's H'lands (Tanah Rata)	66.6	67.5	62.2	70.6	58.7	54.7	75	1st	52	20th	65	14th	61
Cameron's H'lands (Bt. Mentigi.)	65.8	65.6	..	70.4	60.5	56.8	75	1st	57	26th	62	14th	61
Fraser's Hill ...	65.5	68.2	63.8	71.0	61.5	58.8	76	17, 18	59	28th	64	14th	68
Maxwell's Hill ...	70.1	69.1	66.7	73.2	65.1	..	76	1, 22	64	Sev	69	13th	66

RAINFALL ST[...]

Perak. —	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	
Kuala Kurau ..	8.17	207.5	86.8	3rd	20	Bagan Datoh ..	11.55	293.4	40.1	23rd	19	Sabak Bernam ..	11
The Cottage ..	25.87	657.0	89.5	28th	26	Sungkai ..	19.83	491.0	133.0	10th	24	Dist. Hosp., K.L.	15
												Genl Hosp., K.L.	15
												Klang	11
												P. Swettenham.	12

MALAYAN METEOROLOG

ABSTRACT OF METEOROLOGICAL (

Air Temperature in degrees Fahrenheit.

STATION.	Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
Perak—													
Taiping ...	81.7	85.5	77.0	89.7	72.8	72.8	93	21st	69	24th	87	Sev	75
Kuala Kangsar ...	79.0	86.8	76.8	89.9	69.2	..	98	22nd	64	7th	86	5,28	75
Batu Gajah ...	80.9	86.8	76.4	89.9	72.5	..	94	21st	70	6th	88	Sev	77
Gopeng ...	81.7	85.9	76.2	90.5	72.8	..	94	21st	69	6th	86	30th	76
Ipoh ...	80.8	86.6	76.5	91.8	71.8	..	95	20th	69	7,12	85	31st	78
Kampar ...	80.0	87.2	75.9	90.2	71.4	..	92	Sev	69	2nd	86	29,31	74
Teluk Anson ...	80.8	85.7	77.2	90.8	75.0	..	92	Sev	70	21st	88	30,31	80
Tapah ...	81.0	86.5	75.2	90.5	71.8	..	94	11,21	69	11,18	88	31st	78
Parit Buntar ...	88.0	84.9	76.8	88.1	72.7	..	90	12,21	70	1, 7	85	7th	75
Bagan Serai ...	81.8	85.1	77.6	89.0	72.7	..	92	21st	70	Sev	86	Sev	74
Selama ...	81.8	86.9	77.0	90.5	73.0	..	95	22nd	69	8th	85	30th	79
Lenggong ...	79.8	88.8	76.1	89.8	70.6	..	98	21,28	67	16,22	82	1st	74
Tanjong Malim ...	81.0	86.8	78.8	90.5	70.8	..	98	11,18	69	Sev	88	Sev	72
Grik ...	77.4	85.1	75.2	88.5	71.9	..	98	23rd	69	Sev	84	31th	75
Klian Intan ..	76.2	81.2	70.8	86.2	68.6	..	91	22nd	65	25th	80	7th	72
Kroh ...	76.4	79.8	71.7	84.1	68.9	..	89	28rd	61	1st	77	1st	73
Tanjong Rambutan ...	81.2	88.2	76.8	91.8	71.9	..	94	16 21	69	6th	89	Sev	78
Sitiawan ...	81.7	85.8	75.5	88.4	72.7	..	91	11,21	70	12th	85	18th	75
Selangor—													
Kuala Lumpur Rly. Hill ...	80.5	83.6	75.6	90.0	71.9	70.1	94	21st	69	7th	81	31st	74
K.L. Inst. for Med. Research ...	80.5	84.3	76.6	89.6	72.6	..	93	22 26	70	7th	82	31st	75
Bukit Joram ...	81.1	88.8	76.8	87.5	72.2	71.5	91	20th	69	7th	84	Sev	74
Kajang ...	82.3	83.8	76.0	89.2	67.6	..	93	21st	65	7th	86	18th	69
Kuala Selangor ...	81.2	84.6	75.6	86.1	73.0	..	89	18th	70	15th	84	Sev	75
Serendah ...	80.4	83.5	75.7	89.3	71.9	..	92	Sev	70	15,16	86	4,9	74
Kuala Kubu ...	80.2	84.4	74.7	89.3	70.7	..	92	Sev	69	Sev	84	31st	78
Telok Datoh ...	..	..	..	84.7	72.5	..	91	22nd	70	7th	85	Sev	74
Negri Sembilan—													
Seremban ...	82.1	86.1	76.9	88.9	71.6	..	91	7,28	70	Sev	87	Sev	78
Kuala Pilah ...	..	..	.	88.7	70.5	..	92	19th	68	19th	85	18.31	75
Tampin ...	82.1	85.0	75.4	88.8	65.8	..	92	16th	64	Sev	86	Sev	72
Port Dickson ...	81.8	84.8	78.8	85.5	74.5	..	87	Sev	72	Sev	83	9,31	76
Jelebu ...	79.3	86.9	74.5	88.5	70.7	..	91	21st	68	7,16	86	Sev	73
Pahang—													
Kuala Lipis ...	78.0	90.8	76.6	92.7	70.6	..	94	Sev	69	Sev	89	6th	72
Raub ...	78.5	85.5	74.5	88.8	70.5	08.9	98	10th	67	11th	84	28,30	74
Bentong ...	79.2	86.6	75.2	91.0	71.7	..	96	11th	69	Sev	85	31st	74
Pekan ...	81.4	84.7	75.4	89.2	72.2	..	92	12th	71	Sev	81	29th	74
Kuantan ...	80.1	85.1	76.9	88.1	72.5	..	98	11th	71	Sev	83	31st	74
Temerloh ..	77.9	86.0	74.9	89.2	71.8	70.8	93	21st	69	12th	83	31st	74
Hill Stations—													
Cameron's H'lands (Tanah Rata)	65.6	67.7	61.6	70.8	57.5	52.6	74	14th	49	25th	68	Sev	61
Cameron's H'lands (Bt. Mentigi.)	64.0	65.7	..	70.3	58.7	55.0	74	14th	54	7th	66	4th	59
Fraser's Hill ...	66.6	70.0	64.8	78.6	61.1	56.7	80	16th	58	7th	67	4th	68
Maxwell's Hill ...	69.1	70.2	67.4	78.6	6 47	..	77	2nd	61	7th	71	Sev	67

RAINFALL ST

Perak. —	Total. ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	
Kuala Kurau ..	6.71	170.4	47.0	29th	17	Bagan Datoh ..	7.47	189.8	38.4	7th	11	Sabak Bernam.	4
The Cottage ..	16 29	413.9	45.4	29th	20	Sungkai ..	11.42	290.0	71.0	21st	19	Dist. Hosp., K.L.	11
												Genl. Hosp. K.L.	10
												Klang ..	12
												P. Swettenham	1[illegible]

ABSTRACT OF METEOROLOGICAL OB[SERVATIONS]

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
PERAK—													
Taiping ...	80.9	83.4	75.9	89.1	72.5	72.5	93	1,2	70	6th	85	Sev	74
Kuala Kangsar ...	78.3	82.7	76.3	88.3	68.0	..	92	2,27	65	30th	82	30th	70
Batu Gajah ...	79.0	86.8	76.1	89.7	72.4	..	94	1st	69	29th	82	5th	75
Gopeng ...	80.7	84.9	75.8	89.6	72.5	..	94	2nd	69	29th	85	5th	76
Ipoh ...	79.9	85.8	75.5	90.3	72.5	..	93	Sev	69	13,30	83	29th	75
Kampar ...	79.5	85.9	75.3	90.7	72.4	..	93	9th	70	13,18	87	18th	76
Teluk Anson ...	79.7	84.9	76.2	89.3	..	..	93	1st	..	..	88	5th	..
Tapah ...	80.3	84.4	75.0	89.7	71.7	..	93	1,21	69	30th	82	30th	73
Parit Buntar ...	81.9	84.6	76.8	88.6	72.9	..	93	7th	70	16th	88	12th	75
Bagan Serai ...	80.0	85.7	76.9	88.6	71.9	..	93	7th	69	16th	81	29th	74
Selama ...	79.6	85.4	76.1	89.6	72.0	..	93	Sev	68	5th	88	30th	74
Lenggong ...	78.1	87.6	74.2	88.6	71.8	..	91	Sev	67	8th	88	13th	74
Tanjong Malim ...	79.4	85.8	74.1	89.7	70.6	..	93	14th	68	7th	85	15th	78
Grik ...	77.0	84.1	75.1	87.8	72.7	..	92	Sev	69	16th	80	30th	77
Klian Intan ...	75.1	83.9	70.4	86.9	69.2	..	92	11th	66	5th	80	30th	72
Kroh ...	76.5	79.3	71.1	83.4	69.5	..	88	24th	67	30th	78	30th	72
Tanjong Rambutan ...	80.0	85.5	75.6	90.2	72.2	..	93	21st	69	12,29	80	16th	74
Sitiawan ..	80.5	85.2	75.6	88.1	72.7	..	91	Sev	70	16,30	81	29th	75
SELANGOR—													
Kuala Lumpur Rly. Hill ...	79.2	84.9	75.8	89.5	72.0	70.0	94	3rd	69	2,16	81	5th	74
K.L. Inst. for Med. Research ...	79.6	85.5	76.7	89.8	72.8	..	93	3rd	70	2,16	81	5th	76
Bukit Jeram ...	79.9	85.2	76.5	87.3	72.4	71.6	93	4th	69	16th	81	12th	75
Kajang ...	81.8	84.5	77.0	89.6	69.5	..	94	3rd	65	30th	83	29th	72
Kuala Selangor ...	80.3	85.2	77.0	86.1	73.7	..	89	Sev	71	Sev	82	29th	76
Serendah ...	80.7	84.1	76.0	89.7	71.5	..	94	3,4	69	13,16	86	6,18	74
Kuala Kubu ...	79.6	84.2	74.8	89.5	71.3	..	94	14th	68	16th	80	29th	74
Telok Datoh ...	..	..	..	88.2	72.5	..	92	23rd	70	12th	84	12,28	74
NEGRI SEMBILAN—													
Seremban ...	80.6	84.9	76.4	89.1	71.6	..	92	4,7	70	Sev	87	10,16	74
Kuala Pilah ...	..	..	..	89.6	70.8	..	93	3rd	66	23rd	85	12th	74
Tampin ...	81.6	85.2	77.7	83.8	67.8	..	90	Sev	65	9th	84	18,24	70
Port Dickson ...	80.8	83.9	78.3	85.3	74.1	..	87	Sev	70	9th	83	Sev	76
Jelebu ...	79.5	86.6	74.4	88.8	70.5	..	93	3rd	68	1,8	84	29th	73
PAHANG—													
Kuala Lipis ...	77.3	90.4	76.0	92.6	70.9	..	94	Sev	69	Sev	90	9,18	72
Raub ...	77.8	84.8	75.2	88.1	71.0	70.3	91	8th	67	1st	88	30th	73
Bentong ...	78.9	87.3	75.9	91.5	71.6	..	95	3rd	68	1st	85	5th	74
Pekan ...	82.0	84.5	75.8	89.5	71.6	..	91	Sev	69	18th	87	7,30	74
Kuantan ...	81.8	84.9	77.6	88.5	72.9	..	93	7th	71	13th	86	4,5	75
Temerloh ...	78.9	87.0	75.6	89.7	72.0	71.0	93	14,25	70	Sev	82	5th	74
HILL STATIONS—													
Cameron's H'lands (Tanah Rata)	65.2	67.7	61.8	70.5	58.7	54.8	75	26th	54	17th	64	29th	62
Cameron's H'lands (Bt. Mentigi.)	63.4	65.8	..	69.7	59.2	56.2	74	26th	55	30th	62	29th	59
Fraser's Hill ...	67.1	70.1	64.4	73.4	61.8	56.6	77	Sev	59	30th	70	5,15	68
Maxwell's Hill ...	69.1	70.1	67.2	73.1	65.1	..	77	8th	61	30th	68	29th	61

RAINFALL STA[TISTICS]

Perak. —	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—
Kuala Kurau ..	13.38	339.9	55.4	29th	19	Bagan Datoh ..	14.44	366.9	75.1	7th	17	Sabak Bernam ..
The Cottage ..	21.37	542.9	100.2	20th	21	Sungkai ..	12.74	323.5	49.5	24th	20	Dist. Hosp., K.L.
												Genl Hosp., K.L.
												Klang ... ..
												P. Swettenham

STATION.	Air Temperature in degrees Fahrenheit.												
	Means.						Absolute Extremes.						
	9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
PERAK—													
Taiping ...	82.0	87.3	77.5	91.5	71.2	71.2	94	Sev	66	14th	88	26,30	74
Kuala Kangsar ...	78.9	85.2	76.9	91.7	71.4	..	94	6, 22	70	Sev	89	27,31	73
Batu Gajah ...	80.3	89.7	77.6	92.5	72.5	..	97	12th	70	10th	84	11th	75
Gopeng ...	81.5	89.0	76.5	91.7	74.7	..	94	Sev	71	Sev	89	11,18	78
Ipoh ...	80.7	89.6	77.5	92.6	71.8	..	95	Sev	70	Sev	87	11th	75
Kampar ...	79.8	88.8	76.7	91.8	72.1	..	94	2nd	70	Sev	90	Sev	76
Teluk Anson ...	80.7	89.3	77.5	91.0	74.8	..	94	21st	72	Sev	85	11th	79
Tapah ...	80.7	88.6	75.6	92.7	71.2	..	95	1,24	68	24th	90	Sev	75
Parit Buntar ...	82.7	88.8	77.5	90.4	73.2	..	93	18th	70	12th	80	30th	75
Bagan Serai ...	81.4	87.9	77.7	91.2	71.3	..	94	17th	69	12,27	89	26,30	74
Selama ...	81.1	88.8	77.5	92.7	71.0	..	95	Sev	68	21st	88	30th	74
Lenggong ...	78.6	87.9	75.2	90.1	70.7	..	94	24th	66	29th	86	Sev	75
Tanjong Malim ...	80.5	88.2	75.0	91.7	69.8	..	95	21st	65	18th	88	18,30	72
Grik ...	76.2	85.5	75.0	89.8	71.7	..	93	21st	70	Sev	85	Sev	74
Klian Intan ..	75.4	83.9	71.0	88.3	68.8	..	92	10th	66	21st	85	7,29	71
Kroh ...	77.3	83.9	71.6	86.5	69.3	..	90	17th	66	29th	82	22nd	72
Tanjong Rambutan ...	81.1	90.6	77.5	92.1	71.8	..	95	Sev	70	Sev	90	20th	75
Sitiawan ...	82.1	87.6	76.4	90.8	72.1	..	94	17th	70	Sev	82	11th	74
SELANGOR—													
Kuala Lumpur Rly. Hill ...	80.1	88.2	77.6	91.2	71.0	68.6	95	Sev	67	18th	86	16th	73
K.L. Inst. for Med. Research ...	80.6	88.8	78.6	91.4	71.8	..	95	23rd	68	18th	86	11th	74
Bukit Jeram ...	80.6	86.2	77.7	88.7	71.9	71.2	91	Sev	70	Sev	84	11th	74
Kajang ...	81.5	89.3	77.0	91.5	70.9	..	95	14th	70	Sev	88	30th	72
Kuala Selangor ...	81.3	86.5	77.7	87.4	73.2	..	89	Sev	72	Sev	84	30th	75
Serendah ...	82.6	87.7	78.2	91.8	71.9	..	95	24th	69	14th	89	Sev	75
Kuala Kubu ...	81.5	87.8	75.1	92.3	70.6	..	96	21st	67	18th	87	30th	72
Telok Datoh ...	..	..	..	88.9	72.3	..	92	17,27	70	1st	86	Sev	74
NEGRI SEMBILAN—													
Seremban ...	81.7	87.8	76.9	89.9	71.6	..	93	18th	70	Sev	87	9, 11	74
Kuala Pilah ...	..	..	.	89.9	70.2	..	93	19th	67	19th	83	11th	73
Tampin ...	82.2	87.0	76.0	88.7	66.9	..	92	18th	65	2, 8	88	11th	69
Port Dickson ...	81.5	85.6	79.3	86.7	73.5	..	89	17,18	70	1st	85	Sev	76
Jelebu ...	79.7	88.9	78.5	90.1	69.8	..	93	13,15	68	27,28	87	28th	71
PAHANG—													
Kuala Lipis ...	77.6	91.1	76.9	92.9	70.7	..	95	22nd	67	26th	90	26th	72
Raub ...	77.7	84.8	74.8	89.0	69.4	68.2	93	6th	65	4th	86	9th	72
Bentong ...	78.8	88.0	75.3	92.0	70.3	..	95	7th	69	Sev	84	11th	75
Pekan ...	82.6	85.9	76.2	90.6	71.3	..	93	25,26	69	Sev	89	Sev	74
Kuantan ...	81.8	86.3	77.8	88.8	72.5	..	93	17th	69	26th	82	11th	75
Temerloh ..	78.2	88.8	76.7	91.0	71.7	70.7	94	8,21	68	18th	88	11th	74
HILL STATIONS—													
Cameron's H'lands (Tanah Rata)	65.6	69.8	61.0	72.4	55.6	50.6	76	3,12	48	21st	67	11,31	61
Cameron's H'lands (Bt. Mentigi.)	64.5	67.7	..	72.0	59.6	56.3	76	Sev	56	29.31	64	11th	60
Fraser's Hill ...	68.8	70.1	64.9	74.5	61.8	58.4	76	Sev	60	Sev	67	11th	63
Maxwell's Hill ...	70.5	71.9	68.7	75.8	65.4	..	79	17,20	62	Sev	72	31st	69

RAINFALL S

Perak.												
—	Total.		Most in a day.	Date.	No. of rainfall days.	—	Total.		Most in a day.	Date.	No. of rainfall days.	—
	Ins.	m.m.	m.m.				Ins.	m.m.	m.m.			
Kuala Kurau ..	3.04	77.2	33.8	9th	7	Bagan Datoh ..	4.81	122.2	52.3	7th	6	Sabak Bernam,
The Cottage ..	10.70	271.8	84.0	2nd	18	Sungkai ..	3.40	101.5	80.0	15th	13	Dist. Hosp., K.L.
												Genl. Hosp. K.L.
												Klang ..
												P. Swettenham

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
PERAK—													
Taiping ...	83.3	89.5	78.5	92.5	71.6	71.6	95	30th	69	Sev	90	18th	74
Kuala Kangsar ...	79.2	90.8	77.5	92.3	72.5	..	94	Sev	70	29th	89	21st	74
Batu Gajah ...	81.7	90.2	78.3	92.8	73.2	..	97	30th	68	3rd	90	21st	80
Gopeng ...	82.5	90.8	77.5	92.8	76.4	..	97	30th	73	20th	90	21,27	81
Ipoh ...	81.7	90.2	78.8	92.9	71.2	..	96	30th	67	4th	91	Sev	75
Kampar ...	80.0	89.7	77.7	91.7	72.0	..	94	4th	68	4th	90	1,11	76
Teluk Anson ...	81.4	86.8	78.3	90.6	..	..	92	Sev	..	..	88	20th	..
Tapah ...	81.8	90.4	76.4	92.8	70.8	..	95	5,31	67	6th	90	21st	73
Parit Buntar ...	84.4	89.4	77.9	90.8	72.7	..	98	7,12	70	Sev	86	17th	76
Bagan Serai ...	83.1	89.4	80.0	91.8	70.1	..	98	Sev	67	4th	87	17th	75
Selama ...	81.2	91.1	78.9	92.9	71.2	..	98	30th	69	Sev	88	17th	79
Lenggong ...	79.8	89.8	75.8	90.3	69.7	..	93	Sev	67	3, 4	86	18th	73
Tanjong Malim ...	81.0	89.9	75.4	91.8	68.6	..	95	31st	68	4th	88	20th	72
Grik ...	75.8	86.6	74.4	89.3	71.8	..	92	12th	68	4th	86	17th	75
Klian Intan ...	75.9	85.6	71.0	88.5	68.3	..	92	12th	65	4th	86	Sev	71
Kroh ...	76.6	83.6	71.4	85.9	68.6	..	89	Sev	65	22nd	81	18,28	72
Tanjong Rambutan ...	82.3	91.0	77.8	92.9	71.7	..	97	31st	68	4th	90	19,21	75
Sitiawan ..	82.4	88.0	77.6	91.1	72.2	..	93	15,30	70	Sev	89	19,21	76
SELANGOR—													
Kuala Lumpur Rly. Hill ...	80.8	86.1	77.0	88.9	70.7	68.4	93	28th	66	4th	84	10th	74
K.L. Inst. for Med. Research ...	80.7	86.7	78.2	89.7	71.5	..	94	28th	66	4th	86	10th	75
Bukit Jeram ...	81.9	86.9	78.5	89.3	72.8	71.9	91	Sev	70	4,15	86	20th	75
Kajang ...	82.4	88.9	77.2	90.4	71.1	..	95	28th	68	4th	85	10th	76
Kuala Selangor ...	82.8	86.7	78.7	87.0	73.1	..	90	30th	71	12th	82	3rd	76
Serendah ...	82.2	87.7	79.3	91.8	70.7	..	94	Sev	68	5,27	89	21st	73
Kuala Kubu ...	82.4	87.8	75.2	91.7	72.3	..	96	30th	63	4th	88	Sev	74
Telok Datoh ...	..	..	..	88.5	72.2	..	92	28th	70	4th	86	Sev	74
NEGRI SEMBILAN—													
Seremban ...	81.4	87.4	76.7	89.0	71.9	..	92	7th	70	Sev	85	12th	74
Kuala Pilah ...	..	..	..	89.0	70.6	..	98	28th	67	5th	84	11,22	76
Tampin ...	81.1	85.8	75.7	83.5	68.7	..	92	Sev	64	15.20	88	15th	74
Port Dickson ...	81.6	85.0	78.9	86.2	73.3	..	88	2,28	69	15th	84	15,22	76
Jelebu ...	78.0	87.4	78.9	88.3	69.6	..	91	Sev	66	4th	85	12th	72
PAHANG—													
Kuala Lipis ...	77.9	90.7	77.0	92.6	70.5	..	94	9,15	69	Sev	90	Sev	72
Raub ...	78.2	86.1	74.7	89.0	69.0	68.2	91	Sev	66	Sev	84	11th	78
Bentong ...	78.7	88.8	74.0	92.2	70.3	..	95	12th	60	26th	86	4th	74
Pekan ...	82.8	86.1	75.4	89.5	72.1	..	91	Sev	68	4th	83	Sev	74
Kuantan ...	82.2	86.2	78.7	88.9	72.8	..	98	7th	70	26th	86	11th	77
Temerloh ...	77.8	86.7	76.6	89.4	71.6	70.2	98	30th	69	10,28	86	Sev	74
HILL STATIONS—													
Cameron's H'lands (Tanah Rata)	65.7	70.8	60.4	72.7	54.4	49.8	79	30th	45	4.5	70	27th	60
Cameron's H'lands (Bt. Mentigi.)	64.1	69.4	..	72.0	59.8	56.5	78	30th	57	21,22	68	27th	60
Fraser's Hill ...	67.1	71.2	65.3	73.8	62.1	58.6	78	30th	60	15th	70	11th	64
Maxwell's Hill ...	70.3	73.2	69.8	76.5	66.3	..	79	30th	63	10,15	72	17th	68

RAINFALL ST

Perak. —	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—
Kuala Kurau ..	0.63	16.0	14.2	15th	2	Bagan Datoh ..	0.93	23.5	17.0	15th	2	Sabak Bernam..
The Cottage ..	3.50	88.9	37.4	18th	5	Sungkai ..	2.24	57.0	36.0	20th	6	Dist. Hosp., K.L.
												Genl Hosp., K.L.
												Klang ... ..
												P. Swettenham..

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
PERAK—													
Taiping ...	82.1	87.0	77.3	91.8	72.1	72.1	94	Sev	70	27,30	85	26th	74
Kuala Kangsar ...	79.2	87.8	77.4	90.8	73.1	..	94	8th	70	14th	85	29th	76
Batu Gajah ...	80.5	88.8	77.8	90.8	73.1	..	96	4th	71	6, 15	83	5th	77
Gopeng ...	81.3	89.5	76.0	91.3	75.7	..	94	3rd	72	15th	85	26th	79
Ipoh ...	80.8	89.5	77.6	91.7	72.9	..	95	3, 13	70	13th	85	26th	75
Kampar ...	79.1	89.0	77.8	91.8	72.4	..	94	Sev	70	3.4	87	29th	75
Teluk Anson ...	80.2	86.1	78.1	89.5	77.2	..	93	Sev	70	1st	82	28th	80
Tapah ...	81.1	88.2	76.7	91.7	71.8	..	95	Sev	70	Sev	85	29th	75
Parit Buntar ...	82.7	89.0	78.4	90.3	73.2	..	93	Sev	71	Sev	83	17, 26	76
Bagan Serai ...	81.2	87.7	78.7	90.5	71.0	..	93	1, 4	69	Sev	82	17th	74
Selama ...	80.2	89.3	78.0	91.2	72.4	..	95	6, 7	70	Sev	82	26th	76
Lenggong ...	79.4	88.7	76.8	90.1	71.6	..	93	Sev	66	9th	88	29th	74
Tanjong Malim ...	80.1	89.5	75.4	91.1	69.9	..	96	3rd	67	10,12	86	1, 25	72
Grik ...	77.5	85.4	74.6	89.0	72.7	..	93	6, 7	71	Sev	81	28th	76
Kilan Intan ..	76.7	83.2	70.8	87.6	69.2	..	90	Sev	66	4th	80	17th	72
Kroh ...	77.9	83.8	72.1	86.3	69.8	..	89	Sev	67	13th	80	27th	72
Tanjong Rambutan ...	81.6	90.8	76.3	92.6	72.3	..	95	Sev	70	30th	89	27th	74
Sitiawan ...	81.8	86.3	78.0	89.8	73.4	..	94	4th	70	13th	86	25th	76
SELANGOR—													
Kuala Lumpur Rly. Hill ...	80.5	84.9	76.3	90.0	71.6	69.8	93	Sev	70	Sev	85	28th	74
K.L. Inst. for Med. Research ...	80.8	85.9	77.8	90.3	72.4	..	95	3rd	70	12, 13	86	28th	75
Bukit Jeram ...	81.7	84.8	76.9	88.5	72.7	72.0	93	3rd	70	12th	86	Sev	75
Kajang ...	81.0	86.5	77.3	90.2	71.4	..	96	7th	69	14th	85	28th	74
Kuala Selangor ...	82.1	85.4	..	87.0	74.0	..	93	3rd	72	Sev	82	21, 22	76
Serendah ...	82.3	86.5	76.6	90.8	71.7	..	95	4th	69	Sev	86	29th	74
Kuala Kubu ...	81.5	86.5	75.1	90.9	70.3	..	96	3rd	68	Sev	85	28th	73
Telok Datoh ...	..	..	..	88.4	72.8	..	91	Sev	70	13th	84	28th	76
NEGRI SEMBILAN—													
Seremban ...	81.6	86.0	76.9	88.9	71.9	..	92	2, 7	70	16th	86	13, 21	73
Kuala Pilah ...	..	..	..	89.4	71.5	..	92	Sev	69	13 15	83	16, 28	74
Tampin ...	82.4	84.5	76.6	88.6	70.0	..	93	30th	68	Sev	82	16th	76
Port Dickson ...	82.8	85.2	78.8	86.6	74.1	..	89	6, 12	72	Sev	83	16th	77
Jelebu ...	79.4	88.1	74.6	89.4	71.0	..	93	2, 8	68	16,20	86	24th	73
PAHANG—													
Kuala Lipis ...	78.7	91.8	78.0	92.9	72.1	..	94	Sev	69	Sev	90	22nd	75
Raub ...	78.4	85.6	74.8	88.5	70.7	69.8	92	7.14	65	18th	80	28th	75
Bentong ...	79.5	86.6	75.4	91.1	71.4	..	95	13,14	68	22th	85	27, 28	75
Pekan ...	81.7	86.6	76.3	91.0	72.8	..	93	Sev	69	13th	89	Sev	75
Kuantan ...	80.9	86.0	77.4	88.6	72.5	..	93	12th	70	12, 24	82	16, 28	78
Temerloh ..	77.7	87.2	76.3	89.5	72.1	70.8	90	3, 10	68	12, 13	81	27th	75
HILL STATIONS—													
Cameron's H'lands (Tanah Rata)	66.9	69.6	61.7	73.3	57.2	53.1	76	Sev	51	10.14	70	Sev	61
Cameron's H'lands (Bt. Mentigi.)	64.8	68.2	..	72.4	50.1	57.1	77	3rd	54	16th	68	16, 28	60
Fraser's Hill ...	68.9	70.5	65.8	74.1	62.5	59.4	77	7th	60	8th	68	28th	65
Maxwell's Hill ...	70.2	71.8	68.6	76.2	65.8	..	80	3rd	68	Sev	71	26th	69

RAINFALL

Perak. —	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—
Kuala Kurau ..	5.41	137.4	58.9	12th	8	Bagan Datoh ..	2.70	68.6	21.2	29th	8	Sabak Bernam.
The Cottage ..	10.12	257.0	45.0	19th	14	Sungkai ..	5.42	137.7	49.0	21st	8	Dist. Hosp., K.L.
												Genl. Hosp. K.L.
												Klang ..
												P. Swettenham

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	[illegible]
	°F	°F	°F	°F	°F	°F	°F		°F		°F		o
Perak—													
Taiping ...	82.8	86.8	78.8	91.5	73.2	73.1	95	10th	70	1st	87	1st	7
Kuala Kangsar ...	80.2	87.0	77.6	91.8	73.9	..	94	11th	65	29th	88	6th	7
Batu Gajah ...	81.7	88.8	77.9	91.9	74.8	..	96	15th	71	28th	88	4.9	7
Gopeng ...	82.5	88.5	77.0	91.5	76.5	..	95	17th	75	Sev	88	25th	7
Ipoh ...	81.8	88.8	77.5	92.6	73.5	..	95	13, 17	71	17th	89	9,25	7
Kampar ...	81.1	88.9	76.8	91.5	73.2	..	94	26th	70	20th	88	6th	7
Teluk Anson ...	81.8	89.0	77.1	91.2	74.5	..	93	Sev	68	31st	89	Sev	[illegible]
Tapah ...	83.7	89.2	76.8	92.4	73.2	..	94	Sev	71	16th	86	1st	7
Parit Buntar ...	84.0	88.5	78.5	90.7	74.8	..	94	16th	72	29th	88	3, 5	7
Bagan Serai ...	82.8	86.8	78.6	91.2	72.8	..	94	18, 19	70	29, 31	87	5th	7
Selama ...	82.1	89.9	77.5	92.8	74.8	..	94	Sev	72	Sev	87	29th	7
Lenggong ...	80.5	89.1	76.0	91.1	73.0	..	93	Sev	69	19th	87	30th	7
Tanjong Malim ...	80.7	89.6	75.5	91.9	71.8	..	94	10, 28	68	2nd	88	9th	7
Grik ...	79.5	86.7	75.8	90.8	73.7	..	94	14, 18	71	30th	85	29th	7
Klian Intan ...	77.8	85.9	70.5	89.8	70.7	..	93	20th	67	29th	87	7th	7
Kroh ...	78.8	83.6	72.3	87.2	70.5	..	90	6th	67	9th	83	22nd	7
Tanjong Rambutan ...	82.8	89.4	76.5	92.5	72.5	..	94	Sev	71	Sev	90	Sev	7
Sitiawan ...	82.7	86.8	78.5	90.2	74.1	..	93	10, 13	72	Sev	85	1st	7
Selangor—													
Kuala Lumpur Rly. Hill ...	80.7	86.1	77.6	90.6	72.9	71.4	94	3rd	71	Sev	84	9th	7
K.L. Inst. for Med. Research ...	81.4	87.5	79.0	91.0	73.8	..	94	12, 13	72	Sev	86	9th	7
Bukit Jeram ...	82.5	86.4	78.2	89.2	73.9	73.4	91	Sev	69	9th	88	9th	7
Kajang ...	81.0	88.0	77.4	91.0	72.6	..	94	Sev	71	Sev	82	11th	7
Kuala Selangor ...	82.5	85.9	..	87.6	74.9	..	90	8, 10	71	9,14	85	Sev	7
Serendah ...	82.6	88.0	75.8	90.4	72.0	..	94	18th	68	29th	85	10th	7
Kuala Kubu ...	82.0	87.2	76.1	91.8	72.4	..	94	24th	70	1, 19	87	9th	7
Telok Datoh ...	..	..	..	89.4	73.4	..	91	Sev	71	3rd	87	Sev	7
Negri Sembilan—													
Seremban ...	82.4	87.2	77.1	89.9	72.2	..	93	3, 4	70	30th	87	10th	[illegible]
Kuala Pilah ...	..	..	..	90.0	72.8	..	93	17, 18	68	24th	85	9th	[illegible]
Tampin ...	81.9	84.7	76.9	89.8	71.6	..	92	22, 25	70	Sev	88	Sev	[illegible]
Port Dickson ...	81.6	85.2	79.5	86.6	74.8	..	89	24, 27	72	14th	84	20th	[illegible]
Jelebu ...	80.4	88.6	75.4	90.7	71.4	..	93	20, 21	70	Sev	88	27,28	[illegible]
Pahang—													
Kuala Lipis ...	79.0	91.1	77.5	93.0	72.6	..	94	Sev	71	Sev	91	10,12	[illegible]
Raub ...	79.7	86.8	76.1	89.0	72.4	70.4	92	18th	70	17, 26	82	9th	[illegible]
Bentong ...	79.7	87.7	76.1	92.4	71.1	..	93	Sev	71	26th	83	9th	[illegible]
Pekan ...	84.8	88.5	78.1	88.8	71.9	..	91	30th	69	27th	87	Sev	[illegible]
Kuantan ...	81.0	86.4	79.0	89.0	74.0	..	92	25, 26	72	19, 25	85	9,30	
Temerloh ...	79.1	83.8	77.1	89.7	73.4	72.1	94	26th	70	9th	88	9,19	
Hill Stations—													
Cameron's H'lands (Tanah Rata)	68.6	70.8	68.4	74.8	59.2	55.5	77	18th	58	17th	71	1st	
Cameron's H'lands (Bt. Mentigi.)	66.5	68.4	..	73.8	59.7	58.1	76	Sev	56	29th	69	5th	
Fraser's Hill ...	68.1	71.1	67.3	73.3	64.0	60.4	74	Sev	63	7th	70	6th	
Maxwell's Hill ...	71.6	72.2	69.5	76.1	66.9	..	80	8th	65	7, 8	72	1,28	

RAINFALL

Perak. —	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—
Kuala Kurau ..	8.40	213.4	70.6	29th	10	Bagan Datoh ..	5.38	136.7	49.5	27th	8	Sabak Bernam ..
The Cottage ..	26.94	684.3	75.5	20th	20	Sungkai ..	9.25	235.0	33.0	5th	16	Dist. Hosp., K.L.
												Genl. Hosp., K.L.
												Klang ...
												P. Swettenham.

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min	Date.	Lowest max.	Date.	Highest min.
	F °	F °	F °	F °	F °	F °	F °		F °		F °		F °
Perak—													
Taiping ...	82.6	84.3	76.8	91.0	72.4	72.4	94	1st	70	2, 14	86	28th	75
Kuala Kangsar ...	79.2	88.0	76.7	91.8	72.9	..	94	3, 4	68	2nd	89	29th	76
Batu Gajah ...	80.6	87.1	75.9	92.4	73.2	..	95	2nd	70	3rd	88	28rd	77
Gopeng ...	81.7	86.4	76.3	91.1	75.9	..	94	2nd	73	3, 28	87	28th	79
Ipoh ...	81.2	87.2	75.8	92.7	72.4	..	95	15th	69	4th	86	28th	75
Kampar ...	80.5	87.4	76.1	90.7	72.0	..	92	Sev	70	Sev	87	29th	75
Teluk Anson ...	80.7	86.9	76.3	91.2	75.7	..	93	Sev	74	Sev	87	30th	79
Tapah ...	81.8	86.5	74.7	91.7	71.4	..	94	Sev	68	8th	87	29th	75
Parit Buntar ...	83.6	86.8	77.1	89.6	73.6	..	91	Sev	72	Sev	86	28th	75
Bagan Serai ...	82.6	86.7	77.9	90.8	71.9	..	93	1, 4	69	1st	88	30th	77
Selama ...	81.9	86.0	76.5	92.4	73.7	..	95	3, 4	71	14th	89	28, 30	77
Lenggong ...	79.8	90.1	76.3	91.7	72.6	..	94	16th	68	4th	89	27, 30	76
Tanjong Malim ...	81.0	84.7	74.9	91.5	70.5	..	95	2nd	67	29th	87	28th	72
Grik ...	77.7	90.7	76.0	92.6	72.8	..	95	13th	69	3, 4	89	30th	75
Kilan Intan ..	76.2	87.2	70.0	90.6	69.2	..	94	1st	66	5th	87	30th	73
Kroh ...	77.1	84.1	70.6	87.9	68.5	..	90	10th	64	4th	85	24th	72
Tanjong Rambutan ...	81.7	89.8	78.2	92.4	71.9	..	95	4, 22	69	21st	90	Sev	74
Sitiawan ...	81.2	87.8	76.7	88.5	73.1	..	92	2nd	70	Sev	80	13th	76
Selangor—													
Kuala Lumpur Rly. Hill ...	81.2	84.1	75.9	92.3	72.2	70.7	95	7th	69	2, 4	86	30th	76
K.L. Inst. for Med. Research ...	81.8	85.7	76.8	92.0	73.0	..	95	2nd	69	4th	87	28, 30	76
Bukit Jeram ...	84.0	86.8	76.6	90.7	78.1	72.4	94	22nd	71	2nd	86	30th	75
Kajang ...	81.8	85.6	76.7	92.1	71.6	.	94	Sev	68	4th	88	30th	75
Kuala Selangor ...	83.4	86.2	78.2	87.2	74.0	..	89	1st	72	Sev	83	8th	76
Serendah ...	83.4	84.0	74.9	91.5	71.7	..	94	16th	69	2, 5	89	1st	75
Kuala Kubu ...	82.6	84.2	74.8	91.9	71.3	..	94	Sev	68	4th	89	25, 28	74
Telok Datoh ...	..	..	..	89.8	73.1	..	93	15th	70	4th	86	28, 30	75
Negri Sembilan—													
Seremban ...	81.5	85.6	77.1	90.9	71.4	..	92	Sev	70	Sev	90	Sev	74
Kuala Pilah ...	..	..	.	90.6	71.9	..	93	8, 10	67	4th	86	19th	75
Tampin ...	82.4	87.1	75.7	90.8	72.2	..	93	Sev	70	Sev	83	24th	75
Port Dickson ...	83.4	85.8	78.7	87.1	74.2	..	89	22nd	72	2nd	86	Sev	76
Jelebu ...	80.3	88.7	74.4	89.9	71.2	..	92	12,13	68	18th	86	28th	74
Pahang—													
Kuala Lipis ...	79.6	91.1	76.9	92.9	72.6	..	94	Sev	71	Sev	90	4, 16	75
Raub ...	79.7	86.5	76.0	89.3	72.0	70.6	91	Sev	68	4th	86	23rd	74
Bentong ...	80.2	88.6	76.4	92.0	73.8	..	94	7, 12	70	4th	90	Sev	77
Pekan ...	81.9	86.3	78.7	87.8	71.8	..	90	28, 28	70	Sev	85	17, 21	74
Kuantan ...	82.7	86.1	78.1	88.2	73.5	..	90	27, 29	71	Sev	86	1st	75
Temerloh ..	79.2	88.2	77.4	90.9	73.1	71.3	93	9th	70	6th	87	20th	75
Hill Stations—													
Cameron's H'lands (Tanah Rata)	68.5	70.0	62.8	73.2	56.8	52.5	77	20th	47	4th	71	Sev	61
Cameron's H'lands (Bt. Mentigi.)	67.7	67.8	..	72.0	58.9	56.4	75	4, 24	56	Sev	69	28, 30	60
Fraser's Hill ...	66.7	70.5	66.0	72.8	63.3	59.9	75	8th	61	5th	70	24th	64
Maxwell's Hill ...	71.0	72.1	67.9	74.4	66.1	..	76	2, 26	64	Sev	72	17th	69

RAINFALL

Perak. —	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	
Kuala Kurau ..	10.52	267.2	96.9	30th	10	Bagan Datoh ..	3.37	85.7	26.1	20th	11	Sabak Bernam,	[illegible]
The Cottage ..	11.81	300.0	87.1	17th	17	Sungkai ..	10.89	276.5	76.0	23rd	19	Dist. Hosp., K.L.	1[illegible]
												Genl. Hosp. K.L.	1[illegible]
												Klang ..	1[illegible]
												P. Swettenham	[illegible]

STATION.	Air Temperature in degrees Fahrenheit. Means. 9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	F °	F °	F °	F °	F °	F °	F °		F °		F °		F °
Perak—													
Taiping ...	80.7	82.7	76.3	90.9	71.6	71.5	96	2nd	69	6th	84	26th	75
Kuala Kangsar ...	78.8	87.0	76.5	91.8	71.5	..	95	7th	68	1st	85	19th	75
Batu Gajah ...	79.1	86.8	75.8	91.9	72.1	..	96	2nd	70	Sev	86	27th	75
Gopeng ...	80.5	86.8	76.8	90.8	75.7	..	95	2, 7	72	8th	86	27th	80
Ipoh ...	79.9	87.7	76.1	91.9	71.5	..	96	2nd	67	1st	87	27th	74
Kampar ...	78.5	87.9	75.9	90.5	71.5	..	94	10th	68	2nd	87	4th	74
Teluk Anson ...	79.0	85.2	75.8	90.0	76.7	..	93	Sev	72	10th	85	26th	79
Tapah ...	79.8	87.0	75.8	91.5	71.0	..	95	8th	68	8, 9	89	Sev	74
Parit Buntar ...	81.5	85.9	76.8	88.8	78.2	..	91	Sev	71	Sev	85	18th	75
Bagan Serai ...	80.5	85.6	76.2	90.0	70.7	..	94	9th	68	Sev	85	28th	77
Selama ...	79.7	87.1	76.7	92.1	72.7	..	96	2nd	67	9th	86	18th	77
Lenggong ...	79.3	89.4	75.6	90.4	70.7	..	94	22,28	65	1st	84	19th	74
Tanjong Malim ...	79.3	87.3	74.8	90.9	69.7	..	95	2nd	65	3rd	85	29th	72
Grik ...	76.8	87.9	74.3	90.9	70.5	..	94	21st	64	9th	85	17th	74
Klian Intan ...	75.5	86.4	71.3	89.3	66.9	..	92	Sev	60	1st	83	18th	70
Kroh ...	76.5	83.2	72.0	86.7	68.8	..	90	24th	66	6th	81	10th	71
Tanjong Rambutan ...	80.1	90.0	77.9	92.8	72.3	..	95	Sev	70	2, 19	90	Sev	74
Sitiawan ..	81.9	84.7	76.7	88.9	72.3	..	93	20,22	70	Sev	81	28th	75
Selangor—													
Kuala Lumpur Rly. Hill ...	79.6	86.9	75.9	91.5	71.9	70.1	96	1st	69	1, 4	88	28th	73
K.L. Inst. for Med. Research ...	79.9	89.0	76.7	91.9	72.6	..	95	Sev	69	1st	87	18, 28	74
Bukit Jeram ...	80.9	85.7	76.3	89.5	72.8	71.5	92	24th	70	3rd	84	27th	74
Kajang ...	80.0	88.1	76.4	91.5	71.1	..	95	2nd	67	1st	87	18th	67
Kuala Selangor ...	81.5	86.0	78.8	91.2	78.9	..	99	10th	72	Sev	84	7th	76
Serendah ...	79.7	87.0	74.5	90.7	71.3	..	94	21st	69	Sev	86	29th	74
Kuala Kubu ...	80.0	85.5	74.3	91.1	70.9	..	94	Sev	68	1, 8	87	28th	73
Telok Datoh ...	..	..	..	89.7	72.5	..	92	Sev	70	1st	86	27th	74
Negri Sembilan—													
Seremban ...	81.8	86.9	76.8	91.0	71.3	..	92	Sev	70	Sev	90	Sev	73
Kuala Pilah ...	..	..	..	88.3	70.8	..	92	26th	65	1st	81	18th	74
Tampin ...	83.0	85.5	76.5	89.2	71.1	..	93	29th	67	7th	84	17th	75
Port Dickson ...	82.7	85.5	78.7	87.6	73.5	..	92	2, 6	71	1st	83	27th	76
Jelebu ...	79.2	86.8	74.3	88.3	70.5	..	91	11th	66	1st	83	Sev	72
Pahang—													
Kuala Lipis ...	78.2	89.3	76.3	90.9	71.9	..	93	27th	68	1st	84	4th	75
Raub ...	76.7	84.2	74.6	87.5	71.1	69.7	90	Sev	65	1st	82	18th	73
Bentong ...	77.2	86.5	75.1	90.6	71.7	..	94	26, 31	67	1st	84	18th	74
Pekan ...	80.1	82.7	78.4	85.1	73.9	..	90	28th	70	Sev	80	11th	87
Kuantan ...	79.5	82.7	76.9	85.4	72.7	..	92	28th	69	1st	79	4th	76
Temerloh ...	77.8	85.3	75.7	88.1	71.8	70.6	93	24th	66	1st	81	18th	74
Hill Stations—													
Cameron's H'lands (Tanah Rata)	66.8	68.7	61.3	72.7	56.5	52.5	77	24th	48	1st	69	27th	62
Cameron's H'lands (Bt. Mentigi.)	65.9	66.6	..	71.8	58.1	55.8	77	24th	54	1, 9	67	18, 27	[illegible]
Fraser's Hill ...	64.0	68.9	64.5	71.0	62.0	59.7	76	24th	59	8th	65	18th	64
Maxwell's Hill ...	69.1	70.1	67.2	74.4	65.5	..	77	Sev	63	2nd	71	17th	67

RAINFALL

Perak. —	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—	Total. Ins.	m.m.	Most in a day. m.m.	Date.	No. of rainfall days.	—
Kuala Kurau ..	8 97	227.8	44.5	12th	16	Bagan Datoh ..	6.30	160.1	57.8	31st	14	Sabak Bernam ..
The Cottage ..	20.46	519.7	84.9	15th	19	Sungkai ..	9.43	239.5	29.0	16,24	17	Dist. Hosp., K.L.
												Genl Hosp., K.L.
												Klang ... ..
												P. Swettenham.

Air Temperature in degrees Fahrenheit.

STATION.	Means.						Absolute Extremes.						
	9 A.M.	3 P.M.	9 P.M.	Maximum.	Minimum.	Minimum on grass.	Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F
PERAK—													
Taiping ...	80.8	85.6	76.9	91.6	71.4	71.8	94	Sev	69	3, 6	88	11th	75
Kuala Kangsar ...	77.4	89.9	76.7	91.5	71.9	..	94	Sev	70	Sev	85	19th	75
Batu Gajah ...	78.4	88.0	76.4	91.9	72.1	..	94	Sev	69	28th	88	18th	74
Gopeng ...	80.7	87.2	76.6	90.9	74.6	..	94	13th	70	28th	86	15th	79
Ipoh ...	79.4	89.9	77.0	92.6	71.2	..	96	8th	68	28th	84	18th	74
Kampar ...	78.2	87.5	75.7	90.4	71.6	..	93	1, 8	70	Sev	85	18th	76
Teluk Anson ...	78.2	87.6	77.2	90.7	..	..	93	28th	..	..	86	11th	..
Tapah ...	80.2	87.4	76.8	90.7	70.7	..	93	5, 22	68	10, 11	85	18th	78
Parit Buntar ...	80.7	86.9	75.6	88.7	72.2	..	92	Sev	69	16th	88	Sev	74
Bagan Serai ...	79.6	86.3	77.9	90.2	70.2	..	94	10th	68	Sev	85	11th	72
Selama ...	79.4	88.5	77.8	91.9	72.6	..	96	7th	64	6th	81	11th	78
Lenggong ...	79.1	87.0	76.5	91.2	70.0	..	95	8, 12	65	10th	85	19th	74
Tanjong Malim ...	78.9	90.0	75.6	91.9	69.8	..	95	5th	67	5. 8	87	18, 20	72
Grik ...	75.5	87.9	78.1	89.9	69.9	..	98	10,25	64	10th	88	11th	74
Klina Intan ..	74.9	85.4	70.5	88.6	67.8	..	93	Sev	61	11th	82	20th	70
Kroh ...	76.2	84.9	72.8	87.4	67.9	..	91	2, 7	64	7, 9	80	18th	71
Tanjong Rambutan ...	78.4	89.2	77.6	92.6	71.0	..	95	Sev	68	28th	89	15, 20	74
Sitiawan ...	82.9	84.0	76.4	88.7	72.8	..	91	Sev	70	Sev	82	11, 21	77
SELANGOR—													
Kuala Lumpur Rly. Hill ...	78.8	87.3	76.9	90.0	71.4	69.6	95	6th	69	Sev	79	11th	73
K.L. Inst. for Med. Research ...	79.4	88.2	78.1	91.2	71.9	..	95	Sev	66	3rd	81	11th	74
Bukit Jeram ...	79.9	85.7	76.9	89.8	71.6	71.0	94	3rd	70	Sev	80	11th	74
Kajang ...	79.6	87.5	76.3	91.2	70.8	..	95	7th	67	3rd	81	19th	73
Kuala Selangor ...	80.0	88.7	81.5	90.6	73.3	..	99	22nd	72	Sev	85	Sev	76
Serendah ...	79.9	87.4	74.9	90.7	70.7	..	94	Sev	68	3, 5	84	19th	74
Kuala Kubu ...	79.3	86.6	74.4	90.8	70.1	..	95	6th	67	10th	88	11, 17	73
Telok Datoh ...	..	..	..	88.8	71.8	..	93	18th	68	3rd	82	11th	74
NEGRI SEMBILAN—													
Seremban ...	81.1	86.2	77.0	91.6	71.5	..	94	8th	70	15,17	90	Sev	73
Kuala Pilah ...	..	..	..	87.5	71.5	..	92	23rd	62	10th	76	17th	79
Tampin ...	81.1	85.4	75.9	89.2	71.5	..	92	3rd	70	Sev	80	4th	74
Port Dickson ...	81.8	84.2	78.0	86.8	73.1	..	98	3rd	72	Sev	81	20th	75
Jelebu ...	78.7	90.5	74.7	88.0	70.8	..	92	7, 25	75	Sev	76	18, 19	82
PAHANG—													
Kuala Lipis ...	77.8	89.0	75.9	90.7	71.2	..	94	1st	65	2nd	84	17th	73
Raub ...	76.8	84.6	74.9	86.2	70.5	68.9	90	7, 28	68	1, 4	78	18th	73
Bentong ...	76.2	86.4	75.7	90.0	71.5	..	95	23rd	69	3rd	82	18th	73
Pekan ...	79.5	82.0	77.7	88.9	70.0	..	87	6, 28	61	12th	77	18th	73
Kuantan ...	78.8	82.3	77.1	84.7	72.4	..	88	7th	69	2nd	76	17th	75
Temerloh ..	76.5	85.1	75.9	87.4	70.8	69.3	92	7th	67	2, 6	75	11, 18	74
HILL STATIONS—													
Cameron's H'lands (Tanah Rata)	66.3	68.2	60.6	71.4	55.6	51.4	76	18th	45	2, 28	65	11th	63
Cameron's H'lands (Bt. Mentigi.)	65.1	66.2	..	70.5	58.1	55.8	76	18, 25	54	28th	65	17, 18	59
Fraser's Hill ...	68.6	67.9	64.5	70.6	60.8	59.4	75	24, 25	58	28th	63	17th	63
Maxwell's Hill ...	69.3	71.2	67.2	74.8	65.0	..	78	18th	63	27th	72	Sev	67

RAINFALL

Perak.													
—	Total.		Most in a day.	Date.	No. of rainfall days.	—	Total.		Most in a day.	Date.	No. of rainfall days.	—
	Ins.	m.m.	m.m.				Ins.	m.m.	m.m.			
Kuala Kurau ..	7.10	180.3	49.3	15th	11	Bagan Datoh ..	5.03	127.8	31.9	5th	9	Sabak Bernam.
The Cottage ..	3.19	81.0	62.5	25th	6	Sungkai ..	3.37	85.5	26.5	11th	6	Dist. Hosp., K.L.
												Genl. Hosp. K.L.
												Klang ..
												P. Swettenham

ABSTRACT OF METEOROLOGICAL OBSERVATIONS, JANUARY, 1929.

Air Temperature in degrees Fahrenheit.

STATION.	Means. 9 A.M.	Means. 3 P.M.	Means. 9 P.M.	Means. Maximum.	Means. Minimum.	Means. Minimum on grass.	Absolute Extremes. Highest max.	Date.	Lowest min.	Date.	Lowest max.	Date.	Highest min.	Date.
	°F	°F	°F	°F	°F	°F	°F		°F		°F		°F	
Perak—														
Taiping ...	80.2	87.1	76.5	90.9	70.0	69.9	98	Sev	66	18th	80	7th	74	6th
Kuala Kangsar ...	76.7	89.1	76.8	91.0	69.9	..	94	29,30	66	15,17	84	7th	78	Sev
Batu Gajah ...	79.0	88.7	76.1	91.9	71.8	..	94	Sev	69	13th	84	7th	74	1,28
Gopeng ...	80.8	89.4	76.2	91.0	74.5	..	94	28,29	70	6th	84	7th	78	8,18
Ipoh ...	79.8	90.1	75.6	91.9	70.2	..	95	Sev	66	15th	84	6,7	74	24th
Kampar ...	78.8	88.8	76.6	90.1	72.2	..	92	2,22	68	15th	84	8th	[illegible]	[illegible].28
Teluk Anson ...	77.6	87.8	76.8	90.4	..	..	98	1,20	..	...	82	7th	..	..
Tapah ...	80.9	88.8	75.9	91.1	69.9	..	98	21,28	67	14,17	86	7th	78	6,7
Parit Buntar ...	80.6	87.5	75.8	89.6	71.8	..	92	Sev	68	12th	87	6,7	74	7,16
Bagan Serai ...	78.5	85.2	77.8	90.5	69.8	..	98	27th	66	26th	85	6th	72	6,7
Selama ...	78.8	90.8	78.2	92.4	70.8	..	96	29th	62	17th	88	6,7	77	25th
Lenggong ...	76.8	88.9	77.5	90.2	66.9	..	95	29th	62	17th	84	3rd	78	6th
Tanjong Malim ...	78.7	89.5	75.2	91.9	68.9	..	96	8,5	65	28th	84	7th	72	3rd
Grik ...	74.0	88.0	70.8	89.7	68.2	..	94	29,30	62	26th	84	3rd	74	30th
Klian Intan ...	78.8	85.8	70.1	88.6	66.5	..	92	Sev	60	14th	82	6,8	70	Sev
Kroh ...	75.1	84.2	72.9	86.4	66.7	..	91	30,31	61	29th	88	Sev	72	22nd
Tanjong Rambutan ...	78.1	89.8	78.2	91.7	70.6	..	96	28th	66	14th	82	6,7	75	23,31
Sitiawan ...	81.0	86.7	76.6	89.2	71.2	..	98	21,31	68	Sev	88	6th	74	1,6
Selangor—														
Kuala Lumpur Rly. Hill ...	78.8	87.1	75.7	89.9	70.8	68.5	93	29th	68	Sev	82	7th	78	6,25
K.L. Inst. for Med. Research ...	79.5	88.8	76.7	90.5	70.9	..	95	28,29	67	27th	88	2nd	77	25th
Bukit Jeram ...	80.3	85.5	76.9	88.8	71.4	70.7	92	27th	69	11,28	82	7th	78	Sev
Kajang ...	78.8	87.7	77.0	90.8	70.0	..	95	30th	66	18th	84	24th	73	1st
Kuala Selangor ...	82.8	88.1	80.5	89.6	73.8	..	99	15,29	70	19,29	82	24,25	78	28th
Serendah ...	79.8	88.0	74.8	90.5	70.8	..	94	Sev	66	27th	88	8th	74	25th
Kuala Kubu ...	80.1	87.8	74.0	90.8	69.8	..	94	Sev	66	18th	88	7th	72	6,20
Telok Datoh ...	..	..	..	88.1	70.8	..	91	Sev	68	28th	81	6th	78	Sev
Negri Sembilan—														
Seremban ...	82.7	87.6	76.9	91.2	71.6	..	94	28th	70	9th	89	2nd	78	4,18
Kuala Pilah ...	..	..	..	86.8	68.5	..	91	29,31	64	11th	79	7th	78	31st
Tampin ...	79.5	84.7	75.1	89.7	71.8	..	95	24th	70	22,28	86	11th	74	4th
Port Dickson ...	81.4	85.2	77.9	87.2	72.5	..	90	24,28	70	29th	88	7th	74	Sev
Jelebu ...	77.8	86.8	74.1	87.7	69.2	..	92	29th	65	28th	82	4th	72	9th
Pahang—														
Kuala Lipis ...	77.9	87.9	75.1	89.7	70.2	..	94	21,26	68	Sev	81	3,6	72	Sev
Raub ...	75.9	88.9	73.8	85.4	68.9	67.7	91	29,30	68	28th	77	6th	72	Sev
Bentong ...	76.0	86.5	74.3	89.0	70.2	..	95	29th	65	29th	82	6th	73	Sev
Pekan ...	79.1	81.8	75.3	88.4	71.1	..	87	29th	65	28th	74	3rd	79	2nd
Kuantan ...	77.7	81.5	75.8	88.7	70.4	..	87	Sev	67	27th	76	6,7	74	2nd
Temerloh ...	76.1	85.4	75.7	86.8	69.3	68.0	98	30,1	65	27,28	76	6th	73	1st
Hill Stations—														
Cameron's H'lands (Tanah Rata)	65.1	69.1	59.2	71.8	51.8	47.2	75	28,29	42	27,28	66	6th	59	7th
Cameron's H'lands (Bt. Mentigi.)	64.8	67.4	..	71.4	56.8	58.0	76	28,29	58	17th	68	6th	[illegible]	2nd
Fraser's Hill ...	62.8	67.5	68.4	69.4	59.6	58.9	74	15th	57	17,27	64	6th	[illegible]	Sev
Maxwell's Hill ...	69.6	72.0	67.1	74.5	64.6	..	78	27th	62	11th	70	11,12	[illegible]	1,7

Humidity. Means. — **Rainfall.** — **Bright Sunshine.**

STATION.	Depression of Wet Bulb 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure 9 A.M.	3 P.M.	9 P.M.	Percentage 9 A.M.	3 P.M.	9 P.M.	Rainfall Total Ins.	Total m.m.	Most in a day Amount m.m.	Date.	No. of rainfall days.	Sunshine Daily mean Hrs.	Total Hrs.
	°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
Perak—																
Taiping	5.8	10.2	2.2	25.9	25.1	27.2	77	61	89	6.46	164.0	54.5	24th	10	..	..
Kuala Kangsar	4.2	12.8	2.0	24.5	28.8	27.8	81	58	90	8.56	90.5	48.0	11th	8	..	.
Batu Gajah	5.5	12.6	2.2	24.6	28.8	26.8	76	54	89	8.32	84.5	28.8	30th	9	..	...
Gopeng	5.6	11.6	1.8	25.5	25.2	28.4	76	58	94	8.54	89.9	82.0	24th	12	..	..
Ipoh	5.5	13.0	1.3	24.8	28.9	27.8	76	53	94	6.16	156.4	50.9	5th	10	..	..
Kampar	4.4	11.6	2.8	25.5	24.2	26.8	80	57	87	8.86	98.1	21.1	20th	10	..	..
Teluk Anson	3.6	10.8	1.8	26.1	24.9	28.9	84	60	94	5.06	128.5	87.5	25th	7	..	..
Tapah	6.4	10.2	1.8	25.0	26.1	28.1	78	62	94	7.34	186.5	41.9	3rd	14	..	..
Parit Buntar	5.1	9.9	1.1	26.5	25.8	27.8	78	62	95	1.67	42.4	24.4	2nd	8	..	..
Bagan Serai	8.5	7.1	1.5	27.0	27.9	29.1	84	72	93	2.47	62.7	15.7	4th	6	..	..
Selama	4.3	9.9	2.2	26.1	29.1	28.9	81	68	90	2.67	67.8	34.0	2nd	6	..	..
Lenggong	8.8	11.8	2.5	25.0	24.6	27.6	88	56	88	1.44	36.5	24.5	11th	2	..	..
Tanjong Malim	8.5	10.1	1.6	27.2	27.4	27.0	84	68	92	8.00	208.2	74.4	3rd	13	..	..
Grik	2.7	10.1	2.5	24.2	26.0	30.2	87	62	87	1.25	31.7	21.8	3rd	4	..	..
Klian Intan	3.0	9.4	1.7	28.6	24.8	22.5	86	68	91	0.16	4.0	4.0	6th	1	..	..
Kroh	3.6	10.4	1.8	28.9	22.8	24.6	88	59	91	0.51	13.0	13.0	3rd	1	..	..
Tanjong Rambutan	5.3	13.6	3.8	24.1	22.8	26.8	77	51	88	4.71	119.6	46.2	24th	6	...	..
Sitiawan	5.3	7.8	0.5	26.6	28.3	30.0	77	69	98	1.18	29.9	22.9	7th	8	..	..
Selangor—																
Kuala Lumpur Rly. Hill	4.8	11.0	2.0	25.4	24.1	26.8	79	58	90	7.85	199.4	87.0	2nd	14	7.11	220.45
K.L. Inst. for Med. Research	5.5	12.1	2.2	25.0	28.6	27.4	76	55	90	5.50	139.7	47.0	1st	11	..	..
Bukit Jeram	5.2	7.5	2.6	26.1	27.5	27.0	77	70	88	4.68	117.6	84.4	6th	8	8.61	266.90
Kajang	8.8	9.2	1.1	27.6	27.0	29.4	85	65	95	7.07	179.6	58.6	2nd	10	..	..
Kuala Selangor	6.8	12.8	6.9	26.8	22.5	28.9	74	58	70	8.26	209.8	81.8	6th	12	..	..
Serendah	5.4	12.1	1.8	25.4	28.8	27.0	76	55	94	9.41	239.0	40.7	6th	11	..	..
Kuala Kubu	6.0	11.1	1.5	24.8	24.1	26.0	74	58	93	7.80	198.1	38.2	2nd	9	..	..
Telok Datoh	..	..	..	..	..	..	..	..	..	7.35	186.7	58.2	6th	13	..	..
Negri Sembilan—																
Seremban	4.8	9.2	1.1	29.0	27.0	29.8	80	65	95	8.56	217.5	77.4	1st	10	5.92	188.50
Kuala Pilah	..	..	..	..	..	..	..	..	..	6.44	163.6	78.2	2nd	11	..	..
Tampin	4.2	8.8	2.2	26.9	25.0	25.8	81	65	89	4.58	116.3	89.4	6th	8	..	..
Port Dickson	4.7	5.0	1.8	27.9	31.3	30.0	80	79	94	3.88	98.6	52.1	6th	5	..	...
Jelebu	3.1	10.8	1.8	26.5	24.7	26.4	86	61	94	11.52	292.6	71.4	6th	7	..	..
Pahang—																
Kuala Lipis	3.1	10.4	2.8	27.1	25.4	25.8	86	60	89	3.88	97.8	40.7	1st	6	..	..
Raub	3.8	9.2	1.1	25.0	28.6	26.4	85	68	95	8.22	208.8	87.4	3rd	9	..	..
Bentong	3.0	11.0	1.0	25.5	28.6	27.0	86	58	95	4.51	114.9	45.7	3rd	9	..	..
Pekan	4.1	9.1	1.8	26.7	22.1	26.7	82	68	91	9.22	284.6	66.0	6th	7	..	..
Kuantan	4.9	7.1	2.6	25.1	24.5	26.0	81	70	88	9.27	235.5	104.1	2nd	8	..	..
Temerloh	3.2	10.7	3.2	25.3	22.9	25.0	85	59	85	2.39	60.7	32.8	6th	9	6.71	207.90
Hill Stations—																
Cameron's H'lands (Tanah Rata)	4.4	6.2	1.1	15.8	16.4	15.8	77	70	93	3.79	96.4	27.8	2nd	12	6.81	195.60
Cameron's H'lands (Bt. Mentigi.)	4.7	5.1	..	15.3	16.4	..	76	75	..	3.92	99.6	28.0	2nd	10	6.75	208.90
Fraser's Hill	1.8	2.7	1.1	17.7	19.3	18.4	98	86	94	8.66	220.0	50.8	6th	17	5.53	171.85
Maxwell's Hill	5.2	3.4	2.2	17.7	21.7	19.6	75	84	89	8.47	215.1	100.4	2nd	7	..	..

RAINFALL STATIONS.

Perak.

—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.
Kuala Kurau ..	8.86	85.2	38.9	2nd	6
The Cottage ..	11.20	284.5	117.9	1st	7
Bagan Datoh ..	1.36	34.6	20.7	5th	5
Sungkai ..	5.65	143.5	39.0	25th	8

Selangor.

—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.
Sabak Bernam ..	[illegible]	128.2	64.8	6th	5
Dist. Hosp., K.L.	[illegible]	57.0	27.0	7th	8
Genl Hosp., K.L.	[illegible]	199.7	48.0	2nd	14
Klang	[illegible]	147.1	43.7	6th	8
P. Swettenham.	[illegible]	73.2	28.4	12th	10

Negri Sembilan.

—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.
Mantin ..	5.86	148.9	70.4	2nd	7

Pahang.

—	Total. Ins.	Total. m.m.	Most in a day. m.m.	Date.	No. of rainfall days.
Mentakab ..	2.65	67.3	81.8	6th	6
S. Lembing.	6.83	173.5	59.7	6th	12
Rompin ..	7.02	178.3	66.1	7th	8

BSERVATIONS, FEBRUARY, 1929.

Date.	Humidity. Means. Depression of Wet Bulb. 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure 9 A.M.	3 P.M.	9 P.M.	Percentage. 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
	F °	F °	F °	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
2nd	5.0	8.8	1.9	26.9	26.6	28.1	78	67	91	7.32	186.0	44.0	19th	18	..	..
2,22	8.7	12.7	2.1	25.7	24.2	27.5	88	54	90	3.93	99.7	27.5	1st	15	..	..
Sev	4.4	10.8	1.8	25.6	25.0	27.7	80	59	92	5.63	143.0	58.8	11th	10	..	..
5th	5.5	8.9	1.2	26.1	27.0	28.9	76	65	94	4.11	104.4	36.1	23rd	10	..	..
Sev	5.1	12.6	2.1	25.4	24.3	27.8	78	55	90	4.37	111.0	21.2	13th	14	..	..
nd	3.9	10.6	2.4	26.1	24.9	26.1	82	60	88	3.85	97.8	36.8	23rd	10	..	..
	3.4	10.6	1.7	27.0	25.0	28.7	84	60	92	6.86	174.3	45.0	20th	11	..	..
Sev	5.5	10.2	1.7	25.6	25.4	27.8	76	61	92	8.69	220.7	29.2	9.20	15	..	..
Sev	4.6	8.2	1.0	26.5	27.9	28.8	80	68	95	8.60	218.4	55.9	20th	13	..	..
Sev	3.6	8.1	1.7	28.0	27.3	29.3	84	68	92	6.18	157.0	53.1	22nd	8	..	..
4th	3.7	8.4	1.5	27.5	29.1	29.1	83	67	93	10.76	273.4	52.4	22nd	15	..	..
,22	5.2	10.5	1.1	25.0	24.6	28.9	77	60	95	8.39	213.0	65.0	25th	8	..	..
5th	4.2	10.5	1.9	26.3	27.3	26.9	81	61	91	7.39	187.7	51.1	19th	9	..	...
3rd	2.6	9.8	3.6	25.6	26.3	22.2	88	63	83	2.66	67.6	14.9	18th	8	..	..
Sev	3.5	11.5	3.0	22.8	22.0	21.0	82	56	85	5.83	148.2	29.2	13th	11	..	..
Sev	3.8	11.0	1.6	24.6	22.2	24.4	83	57	92	5.30	134.5	37.0	13th	8	..	..
21st	4.7	14.1	4.1	25.2	21.8	25.4	79	50	82	5.78	146.9	38.5	25th	8	..	...
19th	6.0	5.3	0.5	27.3	29.5	29.8	75	78	98	2.98	75.8	25.2	23rd	9	..	..
Sev	4.4	11.0	2.5	26.0	24.2	27.0	80	58	88	3.71	94.2	36.5	13th	16	6.31	176.65
Sev	4.9	11.8	2.9	25.7	23.9	27.6	78	56	86	4.41	112.0	40.9	12th	10	..	..
7, 22	4.7	7.1	2.7	26.5	28.4	26.8	79	72	87	4.80	122.0	29.4	25th	10	7.15	200.25
Sev	3.9	8.6	0.9	27.5	27.9	29.1	82	67	96	8.65	219.7	44.5	12th	13	...	..
4, 26	4.5	8.4	6.8	26.9	24.6	24.9	80	66	72	4.36	110.7	55.9	24th	10	..	..
27th	5.0	11.2	1.2	26.1	24.0	27.2	78	58	94	3.86	98.1	22.3	18th	10	..	..
5, 11	5.1	10.1	1.2	25.4	24.8	26.8	78	62	94	3.47	88.1	30.5	12th	9	..	..
Sev	..	..	..	..	..	..	..	..	..	3.36	85.3	22.1	20th	10	..	..
28th	3.5	8.0	1.2	29.5	27.4	29.3	85	69	94	9.41	239.1	60.4	18th	17	6.06	169.75
26th	..	..	..	..	..	..	..	..	..	3.26	82.8	14.0	11,18	12	..	..
15th	6.3	9.3	2.6	25.2	24.9	26.1	78	63	88	4.86	123.5	27.2	12th	9	..	..
8, 17	4.2	6.3	1.5	28.6	28.1	29.8	82	75	93	3.13	79.5	25.1	24th	8	..	..
7th	3.9	12.7	1.1	26.6	24.5	27.7	82	54	95	2.43	61.7	10.2	22nd	11	..	..
Sev	3.0	11.1	2.0	27.1	25.5	27.0	86	59	90	3.33	84.6	24.1	16th	7	..	..
1, 27	3.4	9.3	1.2	25.6	24.2	26.8	84	63	94	3.78	96.0	21.6	20th	10	..	..
Sev	2.6	10.1	1.2	26.8	24.6	28.0	88	61	94	4.69	119.1	30.5	25th	16	..	..
. 24	6.2	5.0	1.9	24.0	28.1	28.9	73	79	91	32.58	827.5	220.2	11th	11	..	..
2, 25	3.5	6.6	3.0	26.9	25.9	26.5	84	73	86	16.73	424.9	95.5	18th	14	..	..
2nd	2.7	9.6	2.5	26.4	24.2	26.1	87	62	88	5.21	132.3	34.5	23rd	17	5.57	156.00
2nd	4.4	4.9	1.1	16.5	17.1	16.6	77	76	94	5.89	149.7	48.0	11th	16	4.65	130.30
v	3.8	3.6	..	16.4	17.3	..	80	82	..	6.54	166.2	49.5	11th	15	4.84	135.50
21st	1.4	3.4	0.9	18.1	18.7	19.4	93	83	95	3.43	87.1	14.0	18,28	15	4.62	129.25
4th	4.0	2.5	2.1	18.9	22.2	19.8	81	88	89	6.63	168.4	67.0	24th	15	..	..

TIONS.

langor. tal.	Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.		
58.8	27.4	12th	5
66.0	35.0	12th	8
83.6	30.5	12th	11
147.8	45.7	25th	10
111.3	28.5	23rd	8

Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mantin ..	8.04	204.2	55.4	24th	9

Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mentakab ..	4.86	110.7	84.3	24th	6
S. Lembing ..	11.04	280.4	51.1	11th	21
Rompin ..	27.22	691.4	158.4	17th	17

Date.	Humidity. Means. Depression of Wet Bulb 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure. 9 A.M.	3 P.M.	9 P.M.	Percentage 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
	F °	F °	F °	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
22nd	4.8	5.6	1.9	27.0	27.4	27.5	79	76	91	20.26	514.5	62.5	16th	27	..	..
22nd	4.2	9.6	1.6	25.8	25.8	28.2	81	68	98	8.08	205.2	34.8	20th	17	..	..
Sev	4.3	9.6	1.8	26.3	25.2	27.1	81	63	91	9.61	244.0	38.6	20th	18	..	...
Sev	5.0	8.0	1.2	26.6	28.1	28.6	78	69	94	6.09	154.7	24.6	11th	19	..	..
Sev	4.3	9.2	1.1	27.1	27.0	28.6	81	65	95	7.32	186.0	54.7	12th	21	..	.
Sev	4.0	11.0	2.0	26.2	24.7	27.0	82	59	90	9.58	243.8	56.9	30th	16	..	.
Sev	3.8	7.3	1.8	27.0	27.6	28.0	83	71	94	9.87	250.7	52.5	10th	15	.	..
8th	4.8	9.7	1.2	26.2	25.7	27.6	79	63	94	12.26	311.4	75.5	30th	20	..	..
Sev	4.7	6.6	1.7	28.0	29.3	28.3	80	74	92	7.57	192.3	34 3	14th	18	..	..
9th	3.9	7.1	1.2	28.4	28.8	28.5	83	72	94	10.40	264.2	71.9	20th	19	..	..
6.11	3.5	7.4	1.6	28.2	29.3	28.4	84	71	93	14.87	377.8	56.4	23rd	20	..	..
Sev	5.3	12.1	1.7	25.1	24.8	27.1	77	56	92	6.47	164.2	38.0	27th	18	..	..
3.17	3.9	8.9	1.5	27.1	27.1	26.7	89	65	93	14.99	380.8	70.4	26th	19	..	..
8.26	3.0	8.8	3.2	26.2	27.9	23.8	86	66	85	5.25	138.4	44.6	29th	14	..	.
Sev	3.2	11.9	2.8	24.8	22.2	21.9	85	55	86	8.29	210.6	49.0	16th	14	..	..
6.31	3.2	9.3	1.7	25.7	22.9	24.0	85	63	91	11.53	293.0	81.0	14th	13	..	..
Sev	2.6	11.5	1.9	30.0	25.9	29.0	89	58	91	11.51	292.8	98.4	29th	12	...	..
26th	5.1	5.6	1.5	27.8	29.8	28.6	79	77	93	7.48	190.0	65.0	17th	12	..	..
Sev	4.3	10.0	1.9	26.2	25.2	27.1	81	62	91	8.97	227.7	65.9	25th	19	5.57	172.60
Sev	4.6	12.0	2.2	26.7	24.8	27.4	80	56	90	11.01	279.7	93 2	25th	13	.	.
Sev	5.2	6.8	2.0	26.7	28.9	27.8	78	78	90	6.16	156.4	42.8	27th	15	6.54	202.65
1st	4.2	10.2	1.1	27.8	26.0	28.9	81	62	95	10.78	273.8	101.6	15th	21	..	..
Sev	6.0	8.4	4.5	26.0	26.6	25.8	74	67	80	11.70	297.2	81.5	20th	13	..	..
22nd	4.7	10.7	1.2	26.3	24.4	26.9	79	59	94	10.27	260.9	67.8	25th	16	..	.
8th	5.1	9.3	1.0	26.0	25.0	27.0	78	63	95	8.76	222.5	55.6	30th	17	..	..
Sev	..	..	..	..	..	..	..	..	..	7.37	187.2	41.7	31st	18	..	..
27th	4.0	8.8	1.2	29.5	27.0	29.1	83	66	94	8.94	227.1	30.3	27th	19	5.30	164.40
9.30	..	..	..	..	..	..	..	..	..	4.53	115.1	23.6	13th	16	..	..
14th	3.9	9.6	2.4	23.2	24.7	26.9	64	68	88	5.18	131.6	36.8	15th	6	..	..
19th	5.3	6.2	1.4	28.2	29.6	30.6	78	75	93	2.37	60.2	29.2	24th	6	..	...
Sev	4.2	9.8	1.3	26.5	25.4	26.6	81	62	94	2.77	70.4	16.5	27th	9	..	..
22nd	3.3	11.8	2.0	27.0	24.9	27.3	85	56	90	8.27	210.1	37.6	18th	14	..	..
Sev	3.1	8.3	1.3	26.0	25.1	26.9	86	67	94	9.39	238.5	86.4	14th	11	..	..
21.24	3.0	9.4	1.1	26.6	25.7	27.7	86	68	95	12.88	327.2	65.3	15th	23	..	..
28th	3.0	4.3	2.1	29.4	29.8	29.2	87	82	91	16.73	424.9	177.8	12th	14	..	..
19th	4.0	6.2	2.5	27.1	26.9	27.0	82	74	88	19.29	490.0	137.2	11th	19	..	..
26.30	3.3	9.0	2.0	26.7	25.2	26.8	85	64	90	10.48	266.2	49.3	26th	18	5.88	182.30
7th	4.7	4.6	1.2	16.5	17.8	17.0	76	78	93	7.97	202.4	55.5	13th	20	4.39	136.05
Sev	4.6	3.5	..	16.1	17.7	..	77	82	..	7.03	178.5	38.5	13th	19	4.49	139.05
Sev	1.0	2.9	1.0	18.9	20.0	19.3	95	86	95	13.01	332.7	79.5	11th	24	4.20	130.15
Sev	3.0	1.3	1.7	20.1	23.0	20.3	85	94	91	15.27	387 9	71.5	15th	18	..	..

TIONS.

Selangor. Total.	Most in a day.	Date.	No. of rainfall days.	Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.	Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.				Ins.	m.m.	m.m.				Ins.	m.m.	m.m.		
219.9	50.8	31st	12	Mantin ..	5.09	129.3	42.7	30th	15						
91.0	24.0	26th	18							Mentakab ..	10.15	257.8	62.2	18th	11
214.6	94.2	26th	15							S. Lembing.	25.07	636.8	117.9	11th	23
291.9	96.5	12th	11							Rompin ..	13.26	336.8	90.4	15th	13
177.3	41.2	21st	17												

Date.	Humidity. Means. Depression of Wet Bulb. 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure 9 A.M.	3 P.M.	9 P.M.	Percentage. 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
	°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
8th	5.0	6.2	1.9	28.7	28.4	28.0	79	75	91	24.55	623.5	73.0	14th	26	..	..
21st	4.5	9.0	1.4	26.1	27.6	28.7	80	66	93	14.08	357.6	43.5	10th	20	..	..
6th	4.4	8.8	1.5	26.8	27.1	27.7	80	66	93	13.31	338.0	65.0	25th	20	..	..
21st	4.6	6.6	1.1	26.4	29.8	28.8	81	74	95	10.07	255.8	61.7	23rd	25	..	..
21	3.8	7.0	0.9	29.1	30.0	28.7	84	72	96	16.22	411.9	95.8	25th	24	..	..
9th	4.5	9.8	2.1	27.3	25.9	27.0	80	63	90	33.15	842.0	150.9	23rd	24	..	..
5th	3.9	8.2	1.4	28.6	27.9	28.3	83	68	93	19.71	500.5	83.5	30th	22	..	..
30th	5.1	8.7	1.2	27.7	26.7	27.0	79	66	94	17.18	436.4	59.9	25th	23	..	..
Sev	5.3	6.3	1.7	29.1	30.8	28.6	78	75	92	6.56	166.6	50.6	30th	16	..	..
5th	4.6	7.1	1.4	29.2	29.4	28.9	81	72	93	10.70	271.8	108.7	29th	15	.	..
13	4.2	6.9	1.7	29.2	28.9	28.0	82	72	92	17.01	432.0	53.4	18th	24	..	..
Sev	4.0	11.9	1.8	27.5	25.4	27.6	82	56	92	7.17	182.2	84.0	30th	17	..	..
Sev	4.4	6.0	1.8	28.0	29.1	26.3	81	76	91	14.99	380.8	64.8	16th	17	..	...
24	2.7	8.9	2.6	27.5	30.6	26.1	88	67	88	11.35	288.4	59.3	21st	20	..	..
4th	2.7	9.8	1.2	26.1	25.7	23.0	87	63	94	9.31	236.6	62.0	9th	17	.	..
9th	2.9	9.1	2.2	26.7	24.0	22.2	86	66	89	12.64	321.0	63.5	30th	16	..	..
4th	3.3	11.1	1.5	30.3	26.2	30.0	86	60	93	11.45	290.8	52.6	25th	16	.	...
8th	4.0	7.0	0.3	29.8	30.1	29.6	83	72	96	3.08	78.3	23.0	25th	14	..	.
18th	4.3	6.8	0.9	28.4	27.2	28.8	82	72	96	16.80	426.8	75.5	19th	24	6.80	204.00
28th	5.0	7.8	1.5	27.9	27.4	28.7	79	69	93	13.92	353.6	58.3	17th	23	..	..
Sev	6.3	6.8	1.9	27.9	30.0	27.8	74	72	91	2.35	59.8	22.2	23rd	13	8.45	253.60
23rd	4.2	6.3	1.2	29.1	29.5	29.1	82	75	94	14.88	378.0	59.7	23rd	26	...	.
23	6.4	7.5	5.5	27.1	28.2	23.9	73	70	76	3.22	81.8	28.2	30th	9	.	.
23rd	6.3	7.2	1.2	27.3	26.6	27.2	74	71	94	16.95	430.5	75.5	17th	23	.	..
28th	5.9	6.9	0.6	27.1	27.1	28.2	75	71	97	13.77	349.8	49.0	28th	18		..
Sev	.	..	..	..	.	..	.	.	..	3.26	82.8	23.9	21st	15	.	..
2nd	4.1	7.8	1.1	28.9	27.1	29.5	83	69	95	8.16	207.2	19.7	14th	27	6.89	206.15
7th	..	.	.	..	..	..	.	..	.	9.14	232.2	78.7	21st	12	..	..
25	6.4	9.2	1.3	25.7	26.5	27.9	73	65	94	11.54	293.1	49.5	5th	14	.	..
Sev	4.1	4.9	1.2	31.0	32.1	31.1	83	80	94	4.39	111.5	39.1	23rd	8	..	..
3rd	4.6	11.7	1.2	27.0	24.5	26.8	80	57	94	7.69	195.8	35.8	18th	14	..	.
10th	3.4	12.7	2.0	28.8	25.2	27.9	84	55	91	12.88	301.8	65.5	20th	12	..	.
Sev	4.0	9.6	1.3	27.4	25.4	28.2	82	63	94	12.36	313.9	67.3	22nd	17	..	.
30th	4.1	10.6	1.5	27.7	26.1	28.2	82	61	98	8.25	209.5	63.8	8th	15	.	..
2nd	4.0	8.6	2.2	29.5	26.6	29.3	83	67	90	7.48	190.0	93.7	19th	7	..	..
Sev	5.4	7.7	2.6	28.1	27.8	28.1	77	69	88	3.03	77.0	18.0	27th	8	.	..
Sev	3.4	10.9	2.3	27.9	25.2	27.9	84	59	89	3.77	95.8	22.6	20th	14	7.88	236.35
27	4.3	4.0	1.0	18.0	19.4	18.0	79	81	95	13.35	339.0	74.9	23rd	20	5.09	152.60
Sev	3.7	2.5	..	18.2	19.7	..	82	87	.	13.09	332.4	69.8	23rd	19	5.40	102.05
Sev	1.4	3.0	1.0	20.3	21.0	20.3	93	85	95	11.45	290.8	65.8	29th	21	5.67	169.95
10th	3.0	3.1	1.4	21.4	22.2	21.2	86	86	93	17.14	435.4	80.6	17th	22	..	..

TIONS.

langor. Total.	Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.		
150.0	59.8	23rd	7
325.0	56.0	17th	23
445.8	83.3	19th	21
275.3	77.7	28rd	17
186.1	49.8	23rd	16

Negri Sembilan.

—	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mantin ..	9.19	233.4	58.4	18th	17

Pahang.

—	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mentakab .	2.98	75.7	24.1	19th	6
S. Lembing ..	12.27	311.7	68.0	27th	21
Rompin ..	3.37	85.6	29.0	19th	7

AL OBSERVATIONS, MAY, 1929.

	Humidity. Means.									Rainfall.					Bright Sunshine.	
	Depression of Wet Bulb			Vapour Pressure.			Percentage			Total.		Most in a day.		No. of rainfall days.		
Date.	9 A.M.	3 P.M.	9 P.M.	9 A.M.	3 P.M.	9 P.M.	9 A.M.	3 P.M.	9 P.M.			Amount.	Date.		Daily mean.	Total.
	°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
4,12	5.0	7.9	2.0	28.9	28.3	29.2	79	69	91	18.66	474.0	64.0	19th	18	..	..
Sev	3.5	7.7	1.8	28.7	28.8	28.9	85	68	92	5.89	149.5	48.5	5th	11	..	..
16th	5.1	9.8	2.1	27.6	26.7	28.8	79	63	91	11.01	279.6	74.4	1st	10	..	...
19,30	4.9	7.6	1.0	28.7	30.4	29.6	79	71	95	11.46	291.1	44.2	4th	20	..	..
9th	3.9	8.0	1.4	29.6	29.5	29.4	83	69	93	13.28	337.2	66.0	27th	19	..	.
Sev	4.6	10.2	2.2	27.8	26.8	27.5	81	62	90	8.46	214.9	37.8	5th	14	..	.
6th	4.8	10.6	1.5	28.9	26.2	28.9	82	61	93	6.79	172.5	51.5	4th	9	..	..
4th	6.6	9.4	1.5	27.1	28.3	28.7	78	64	93	15.66	397.8	57.2	5th	20	..	..
15th	5.4	7.8	2.3	29.3	30.1	28.9	77	70	90	4.52	114.7	58.2	29th	7	..	..
14,15	4.2	6.7	1.3	30.1	30.1	30.7	82	73	94	2.14	54.4	19.3	29th	5	..	..
17th	4.1	9.4	2.0	29.6	28.9	28.5	88	65	91	14.65	372.0	60.8	29th	17	..	..
7th	3.7	10.3	1.7	28.7	26.1	27.5	84	60	92	12.19	309.5	78.0	4th	13	..	..
Sev	4.5	9.9	1.8	27.5	27.9	26.9	80	68	91	10.13	257.3	37.1	5th	14	..	..
Sev	3.4	6.4	1.5	28.2	30.5	27.6	84	74	93	6.96	176.9	31.7	6th	23	..	..
Sev	2.8	9.6	1.2	27.0	24.9	28.5	87	68	94	6.85	174.0	27.0	14th	18	..	..
20th	2.9	7.3	2.0	27.8	26.1	23.8	86	70	90	5.89	149.5	21.5	13th	15	..	..
Sev	4.5	10.7	1.1	28.1	26.5	28.9	81	61	95	11.80	299.8	54.6	27th	20	...	..
9,18	3.3	4.7	1.0	31.6	33.6	31.2	86	81	95	4.00	101.7	47.4	27th	7	..	..
19,31	3.7	7.3	1.6	28.9	28.5	29.2	84	71	93	6.79	172.4	47.2	15th	17	6.01	186.15
19,31	4.8	8.6	2.2	27.7	27.8	29.6	80	67	90	7.39	187.7	59.7	15th	17	..	..
12,18	5.4	6.9	2.7	27.9	29.3	28.0	77	72	88	4.16	105.6	41.6	4th	10	7.22	228.80
Sev	3.5	7.2	1.8	29.4	30.5	28.7	85	72	92	8.55	217.2	59.9	4th	13	..	..
24th	5.5	7.1	..	27.7	28.6	..	77	72	..	7.11	180.6	56.9	20th	7	..	..
23,27	5.8	10.1	1.3	27.3	26.0	28.0	76	62	94	8.56	217.4	31.8	2nd	10	..	..
Sev	5.2	8.2	1.2	27.7	28.2	28.4	78	68	94	6.85	174.0	49.0	25th	10	..	..
Sev	..	..	..	..	..	..	..	..	..	3.38	85.9	22.6	5th	12	..	..
10,16	4.8	8.8	1.1	28.8	27.2	29.5	80	66	95	8.52	216.5	41.8	3rd	23	..	..
8,9	..	..	..	..	..	..	..	..	..	9.88	250.9	73.7	18th	16	..	..
25th	4.5	5.7	1.4	28.8	29.6	28.9	81	77	93	8.14	206.8	33.0	14th	12	..	..
10th	2.7	3.8	1.3	31.5	33.4	31.7	88	84	94	9.44	239.8	50.8	5th	12	..	...
Sev	4.4	10.3	1.0	27.4	26.2	27.1	80	61	92	9.25	234.8	64.8	11th	14	..	..
4th	2.7	13.1	1.0	28.8	24.7	28.9	88	54	92	13.49	342.7	127.8	19th	12	..	..
Sev	3.2	7.7	1.1	28.7	28.0	28.6	86	70	95	3.36	85.3	25.4	5th	11	..	..
14th	3.6	9.5	1.0	28.1	26.6	28.8	84	64	95	12.02	305.3	86.4	5th	14	..	..
Sev	6.4	5.2	1.6	28.6	29.2	29.7	74	78	93	4.20	106.7	70.9	5th	6	..	..
15th	3.6	7.8	2.3	29.3	28.8	29.4	84	71	90	5.03	127.8	41.9	4th	11	..	..
31st	2.7	10.1	1.3	28.9	26.8	29.2	88	63	94	6.28	159.5	38.9	24th	18	6.29	194.85
Sev	3.7	3.9	0.6	18.8	19.8	19.0	82	81	97	10.43	264.8	37.5	24th	23	4.89	151.55
Sev	2.5	2.9	..	18.8	19.6	..	87	85	..	11.20	284.5	38.4	24th	22	5.00	155.05
Sev	2.3	2.9	1.3	20.2	21.6	20.9	89	86	93	10.05	255.3	36.9	4th	16	4.94	153.05
14,1[illegible]	3.4	3.2	2.4	21.4	22.1	21.0	84	85	88	26.06	662.0	79.2	22nd	19	..	..

ITIONS.

Selangor.					Negri Sembilan.						Pahang.					
Total.	Most in a day.	Date.	No. of rainfall days.	—	Total.		Most in a day.	Date.	No. of rainfall days.	—	Total.		Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.				Ins.	m.m.	m.m.				Ins.	m.m.	m.m.		
56.6	36.2	5th	8	Mantin ..	11.80	299.7	113.8	19th	17	Mentakab ..	4.84	122.9	59.5	24th	9
168.0	33.0	15th	16							S. Lembing.	9.44	239.8	80.0	7th	23
121.3	20.3	5th	13							Rompin ..	2.71	68.8	19.1	5th	11
252.2	66.6	4th	11												
159.3	36.1	4th	11												

OBSERVATIONS, JUNE, 1929.

Date.	Humidity. Means. Depression of Wet Bulb. 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure 9 A.M.	3 P.M.	9 P.M.	Percentage. 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
	°F		°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
ev	5.2	8.8	2.2	27.8	27.0	28.0	78	66	90	6.08	154.5	29.0	17th	14	..	..
th	3.4	9.3	1.3	27.9	26.5	29.5	84	65	94	2.91	74.0	27.0	25th	8	..	..
th	4.9	10.8	2.3	26.8	25.6	28.3	78	60	89	3.13	79.4	36.0	2nd	8	..	..
24	4.8	9.8	0.1	27.4	27.9	30.1	80	63	100	6.30	160.0	48.8	22nd	12	..	..
ev	4.9	11.0	2.1	27.0	27.0	28.5	78	60	90	1.42	36.0	9.6	4th	11	..	..
th	3.9	10.4	3.0	27.0	26.6	27.1	82	61	86	3.19	81.0	30.2	11st	6	..	..
13	4.6	7.2	2.1	27.0	26.6	28.9	80	71	91	5.41	137.3	50.5	30th	12	..	..
5th	5.2	9.3	1.8	26.9	27.3	28.0	78	65	92	8.67	220.2	73.7	25th	10	..	..
8th	5.4	9.4	1.8	28.1	28.1	29.7	77	64	92	4.30	109.2	32.0	17th	7	..	..
8th	4.0	7.8	1.3	28.9	29.2	30.8	83	70	94	2.36	59.9	13.5	17th	8	..	..
2nd	4.3	9.2	2.2	27.4	28.7	28.7	81	65	90	4.11	104.4	38.4	17th	10	..	..
ev	4.0	10.6	1.9	27.0	26.4	28.0	82	61	91	3.92	99.5	64.0	22nd	9	..	..
2nd	4.4	9.6	1.9	27.1	28.5	26.6	80	64	91	3.86	98.1	21.6	1st	11	..	...
6th	2.5	6.7	1.3	27.6	28.7	26.9	88	73	94	3.90	99.1	26.0	19th	14	..	..
6th	3.2	7.9	1.0	25.8	24.8	24.0	85	67	95	3.98	101.2	17.0	26th	12	..	..
Sev	3.4	8.5	1.8	26.7	24.6	24.0	84	66	91	4.49	114.0	34.0	17th	9	..	..
Sev	4.1	12.7	1.1	29.1	25.0	28.8	83	55	95	3.89	98.7	39.0	22nd	13	..	...
Sev	3.4	3.7	0.5	30.4	31.3	31.6	85	85	98	1.99	50.5	21.5	4th	5	..	..
Sev	4.2	7.3	1.8	27.8	27.3	27.6	81	71	92	6.34	161.0	83.8	4th	14	6.14	184.15
.20	4.7	8.3	2.3	27.3	26.7	28.3	79	67	89	6.30	160.0	90.9	4th	15	.	..
.3	5.1	6.5	2.5	27.6	28.5	27.0	79	74	88	2.56	65.0	32.2	10th	10	6.68	200.50
6th	4.0	7.1	1.5	28.7	29.2	29.1	83	72	93	6.22	158.0	35.6	4th	17	...	..
3rd	5.9	6.4	..	26.7	29.1	.	75	76	..	2.90	73.7	20.1	28th	5	..	..
ev	6.1	8.9	2.0	26.6	26.4	27.6	75	65	91	8.31	211.1	56.4	11th	14	..	..
ev	5.6	9.0	1.0	26.7	26.2	27.8	77	65	95	4.87	123.7	37.9	4th	11	..	..
4th	..	..	..	..	..	..	..	..	..	5.16	131.1	72.7	10th	15	..	..
ev	4.2	8.1	1.1	28.9	27.0	29.3	82	68	95	4.49	114.0	33.7	27th	21	..	..
26	.	..	..	.	..	..	..	..	..	7.65	194.3	66.1	7th	13	..	..
30th	5.6	6.5	2.0	27.5	28.2	27.6	77	74	91	4.32	109.7	45.7	20th	10	..	..
ev	3.5	4.8	1.3	30.8	31.7	31.0	85	80	94	4.55	115.6	34.3	17th	10	..	.
6, 9	4.0	10.9	1.4	27.0	25.0	26.7	82	59	93	6.89	175.0	39.4	20th	20	..	..
4th	2.6	13.0	2.5	28.7	25.0	28.2	88	54	88	4.48	113.8	27.9	27th	13	..	..
8th	3.6	7.7	1.1	26.8	27.3	27.8	84	69	95	4.70	119.4	29.2	15th	12	..	..
5th	4.6	8.6	0.8	26.4	27.0	28.4	80	67	97	2.78	70.6	21.6	20th	11	..	..
16th	3.9	6.4	1.3	29.5	30.4	28.5	83	74	94	4.35	110.5	49.8	19, 30	7	..	..
3rd	4.7	7.3	2.2	27.3	28.4	28.1	79	71	90	4.89	124.3	71.4	25th	11	.	..
3. 4	2.6	9.7	1.6	27.7	25.9	28.0	88	63	93	5.84	148.3	93.2	25th	12	5.95	178.65
2th	3.7	4.8	0.8	17.6	18.2	17.6	81	77	95	3.28	83.4	21.4	20th	17	4.84	145.25
ev	3.0	4.0	.	17.1	18.2	..	84	80	..	3.03	76.9	19.1	20th	14	5.11	153.40
th	4.0	3.8	2.8	18.7	20.1	17.9	81	82	86	6.53	165.9	40.7	24th	14	5.03	150.95
th	3.9	3.0	2.3	19.7	22.0	20.5	81	86	89	7.48	190.0	32.4	17th	14	..	..

IONS.

ngor.	Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.		
80.2	40.1	4th	5
86.0	22.0	11th	10
116.8	64.5	4th	11
284.4	89.9	26th	10
162.6	84.9	26th	10

Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mantin ..	3.13	79.5	15.0	23rd	14

Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mentakab ..	5.68	144.3	50.8	20th	9
S. Lembing ..	11.50	292.1	42.9	23rd	16
Rompin ..	6.43	163.3	83.3	28rd	11

OBSERVATIONS, JULY, 1929.

Humidity. Means. Depression of Wet Bulb 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure 9 A.M.	3 P.M.	9 P.M.	Percentage 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
6.8	11.6	8.0	26.5	25.8	27.8	72	58	86	..	..	..	..	..	..	..
3.8	5.9	1.8	27.2	85.4	29.0	88	77	92	0.51	13.0	13.0	19th	1	..	..
6.4	18.2	8.5	25.6	23.7	27.3	73	53	84	0.39	9.8	5.4	21st	2	..	...
6.0	10.6	1.2	27.0	27.4	29.8	75	61	94	1.85	47.0	23.9	20th	5	..	..
5.8	12.8	2.8	26.5	24.2	29.2	76	54	90	1.32	33.6	14.7	25th	6	..	.
5.6	11.9	2.9	25.8	25.0	27.2	76	56	86	0.72	18.3	17.8	23rd	2	..	.
6.0	9.5	2.8	25.9	25.8	28.8	74	63	90	0.47	12.0	12.0	1st	1	..	..
5.8	11.5	1.9	26.6	26.3	27.6	76	58	91	2.55	64.8	32.0	19th	5	..	..
7.9	10.2	1.8	25.8	27.2	29.2	68	62	92	0.25	6.3	6.3	17th	1	..	..
5.2	8.8	2.8	28.8	26.4	29.6	78	63	88	..	..	..	..	..	..	..
4.5	10.7	2.8	28.0	28.2	29.8	81	61	90	0.35	8.8	6.4	17th	2	..	..
5.0	11.0	1.9	26.0	26.9	27.0	78	59	91	2.20	56.0	16.0	31st	6	..	..
4.6	10.5	1.8	27.7	27.2	26.8	80	61	91	2.21	56.1	29.5	20th	4	..	..
1.9	3.7	1.6	27.0	26.8	26.1	91	66	92	3.22	81.7	31.8	14th	6	..	..
2.8	8.9	1.2	25.7	25.5	23.9	87	65	94	3.03	77.0	59.0	26th	5	..	..
2.9	8.7	1.6	26.2	24.2	23.6	86	64	92	1.24	31.5	12.5	31st	5	..	..
5.6	13.7	2.1	27.4	23.8	28.7	77	52	91	0.47	12.0	12.0	17th	1	...	..
5.6	4.8	0.5	27.5	34.6	31.2	77	81	98	0.24	6.2	3.7	21st	2	..	..
5.4	9.2	2.1	26.1	25.5	27.8	76	64	90	2.27	57.6	41.0	18th	10	7.08	217.85
5.2	9.4	2.3	26.5	25.9	28.7	77	63	90	1.76	44.7	17.0	10th	7	..	..
5.3	8.6	3.4	27.4	27.2	27.2	78	67	84	1.22	30.9	16.7	19th	6	8.50	263.35
5.4	9.0	1.6	27.8	28.6	28.9	77	66	93	0.08	2.0	1.5	15th	2	..	..
6.2	8.1	2.8	27.0	27.8	28.4	74	69	87	1.36	47.3	24.1	12th	3	..	..
6.2	10.2	3.2	26.4	25.6	28.3	74	61	85	0.90	22.9	22.9	18th	1	..	..
7.0	10.9	1.1	25.4	24.7	27.7	71	59	95	1.20	30.5	15.7	10th	6	..	..
..	..	..	..	..	..	..	..	..	3.38	85.9	45.2	31st	7	..	..
3.8	9.3	1.0	29.3	26.6	29.3	84	64	95	1.46	37.1	11.6	15th	10	..	..
..	..	..	..	..	..	..	..	..	2.01	51.1	30.5	30th	10	..	..
4.7	10.3	1.2	27.6	23.8	28.1	79	60	94	5.18	131.6	42.7	15th	9	..	..
3.0	4.1	1.4	31.0	32.6	30.8	87	83	93	4.50	114.3	36.6	31st	3	..	...
3.6	10.3	1.3	26.4	25.2	26.2	84	61	94	0.92	23.4	11.7	10th	9	..	..
2.8	12.8	2.6	27.6	24.8	27.0	87	54	88	0.46	11.7	8.1	5th	3	..	..
3.9	9.3	1.6	26.1	25.4	26.5	82	64	92	2.07	52.6	29.7	12th	5	..	..
3.3	10.8	1.4	28.6	25.3	26.1	88	59	93	3.60	91.5	32.0	31st	6	..	..
4.5	6.1	1.2	29.1	30.3	27.7	81	76	94	3.55	90.2	31.8	22nd	8	..	..
5.7	7.4	2.2	27.1	28.4	28.4	76	70	87	0.74	18.8	7.4	10th	6	..	..
2.4	9.2	1.8	27.6	26.1	27.9	89	64	92	4.38	111.3	31.3	14th	13	6.96	215.75
3.4	6.4	0.6	17.3	17.2	17.1	82	70	96	0.67	17.1	8.8	9th	5	6.71	208.05
2.8	5.9	..	16.9	16.8	..	85	72	..	0.78	19.7	9.1	9th	5	7.00	216.90
2.8	5.0	3.4	18.9	19.1	17.0	86	77	82	0.12	3.1	1.0	11th	5	7.31	226.60
4.2	3.8	3.9	19.4	22.1	19.1	80	83	81	2.45	62.2	16.4	13th	6	..	..

S.

...gor.	Most in a day.	Date.	No. of rainfall days.
..m.	m.m.		
..8.5	49.3	15th	2
..1.0	5.0	Sev	13
..8.9	14.2	18th	3
..7.8	12.7	15th	3
4.3	2.0	10th	3

Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mantin ..	3.09	78.5	16.3	12th	11

Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Ment kab ..	3.70	94.0	31.5	10th	8
S. Lembing.	1 40	35.6	9.7	31st	9
Rompin ..	5.50	139.7	29.2	16th	14

...BSERVATIONS, AUGUST, 1929.

	Humidity. Means. Depression of Wet Bulb. 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure. 9 A.M.	3 P.M.	9 P.M.	Percentage. 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
	°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
22	5.7	10.1	2.4	27.0	25.3	27.8	76	62	89	5.10	129.5	84.0	25th	15	..	..
v	4.4	8.5	1.9	26.1	25.8	28.1	80	66	91	4.24	107.7	53.0	16th	6	..	..
st	5.7	12.6	3.1	25.4	24.2	26.9	75	55	86	4.76	120.8	80.6	16th	8	..	..
h	5.0	9.3	1.0	27.6	28.3	29.1	79	65	95	5.84	135.7	24.1	3rd	20	..	..
h	4.8	10.9	1.8	27.0	26.3	28.9	79	60	92	2.79	70.8	16.9	16th	13	..	..
th	4.6	11.4	2.7	26.6	25.0	26.6	80	57	87	7.10	180.3	49.0	25th	15	..	..
	5.6	11.0	1.9	25.9	26.0	28.7	76	59	91	1.43	36.3	17.0	7th	5	..	..
h	4.4	9.9	1.4	27.7	27.0	27.6	80	68	93	5.78	146.8	38.9	24th	13	..	..
h	6.0	10.0	2.0	27.1	27.0	28.5	75	63	91	3.99	101.4	36.3	31st	10	..	..
v	4.9	8.7	1.6	27.6	28.0	29.3	79	67	93	4.37	111.0	57.9	7th	6	..	..
7	4.1	9.0	2.0	28.6	28.5	26.6	83	66	91	9.51	241.6	96.8	25th	14	..	..
l	3.0	10.3	1.7	27.9	25.6	26.8	86	61	92	3.96	100.5	27.0	16th	12	..	..
h	4.8	9.7	1.8	26.9	26.8	26.4	79	64	91	6.28	159.5	44.2	14th	10	..	...
h	2.2	8.3	2.3	26.6	26.8	25.7	89	67	89	4.73	120.1	30.3	10th	15	..	..
v	2.6	8.2	1.1	25.5	25.1	24.1	88	67	94	2.47	62.6	24.0	7th	9	..	..
h	3.3	9.7	0.9	26.2	28.0	24.8	85	61	95	5.47	139.0	25.0	28th	9	..	..
h	6.3	14.4	2.4	25.2	22.6	27.8	73	49	89	2.86	72.6	28.0	23rd	7	..	...
h	3.7	5.4	0.6	30.2	33.2	29.7	84	78	97	4.72	120.0	72.0	11th	8	..	..
v	5.8	11.6	3.1	25.1	24.2	26.9	75	57	86	2.23	56.7	17.7	13th	10	7.42	230.05
h	5.7	11.5	3.0	25.6	24.9	26.1	73	57	86	3.19	81.0	17.0	10th	7	..	..
	5.0	7.6	2.7	26.7	28.1	27.5	78	70	87	5.30	134.5	59.9	10th	12	7.83	242.80
k	6.0	10.8	1.5	26.0	26.2	28.9	74	60	93	2.51	63.8	25.7	14th	11	...	..
7	5.5	9.1	3.9	26.6	26.1	25.6	77	65	82	1.87	47.5	25.4	11th	5	..	..
0	6.9	10.9	2.4	25.7	24.6	28.5	71	59	89	3.06	77.7	30.7	11th	6	..	..
v	6.3	10.7	1.4	25.5	24.6	27.1	73	69	93	8.46	214.9	47.5	10th	13	..	..
26	..	..	..	..	..	..	..	..	..	2.18	55.4	16.8	1st	7	..	..
h	4.1	9.5	1.1	29.2	26.7	29.3	83	64	95	0.92	23.3	9.2	19th	8	..	..
	..	..	..	..	..	..	..	..	..	1.72	43.7	19.1	22nd	7	..	..
7	5.2	8.5	1.3	27.9	27.5	28.2	78	67	94	5.27	133.9	26.2	19th	10	..	..
7	3.4	4.8	1.6	30.1	32.1	31.0	85	80	93	3.72	94.5	35.6	20th	11	..	..
v	4.8	11.8	1.2	26.1	24.6	26.0	79	56	94	1.24	31.5	9.1	2nd	8	..	..
v	2.7	13.2	1.6	27.4	24.6	28.6	87	53	93	3.95	100.3	76.2	2nd	5	..	..
h	3.9	8.3	1.3	25.7	25.7	26.6	82	67	94	4.45	113.0	52.1	15th	11	..	..
h	4.2	10.3	1.5	26.2	25.7	27.1	81	61	93	3.58	90.9	27.2	10th	8	..	..
h	5.3	6.7	1.5	28.1	29.1	28.0	78	78	93	4.06	103.1	56.1	11th	6	..	..
h	5.7	8.0	2.8	26.8	27.5	27.5	76	68	87	5.47	138.9	80.0	8th	9	..	..
h	3.2	11.6	2.4	27.2	24.7	27.0	85	57	88	3.76	95.5	29.0	22nd	15	7.38	228.85
	3.6	4.9	0.6	17.0	17.9	16.8	82	76	96	9.28	234.3	68.9	10th	19	5.87	166.35
	3.1	3.9	..	17.4	17.9	..	84	81	..	9.71	246.7	81.0	10th	17	5.54	171.85
	4.3	4.2	2.0	18.2	19.3	18.3	79	80	89	4.39	111.5	19.8	24th	16	6.66	206.35
	5.1	4.0	3.5	18.4	20.8	19.1	76	81	88	10.21	259.4	36.4	2nd	23	..	..

...ngor.	Most in a day.	Date.	No. of rainfall days.	Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.	Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.				Ins.	m.m.	m.m.				Ins.	m.m.	m.m.		
101.7	48.2	6th	4	Mantin ..	1.47	37.3	16.5	20th	6	Mentakab ..	4 11	104.4	30.5	16th	10
61.0	24.0	6th	10							S. Lembing ..	9.84	237.2	93.3	8th	16
33.3	13.4	13th	6							Rompin ..	5.27	133.9	19.6	8th	13
193.8	73.2	9th	12												
143 3	54.6	13th	11												

ICAL SERVICE.

VATIONS, SEPTEMBER, 1929.

Humidity. Means. Depression of Wet Bulb 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure. 9 A.M.	3 P.M.	9 P.M.	Percentage 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
4.5	6.4	1.7	27.7	27.1	27.4	80	73	92	18.70	475.0	70.5	25th	23	..	..
3.4	5.9	1.6	27.0	27.2	28.0	84	75	93	13.23	336.0	67.0	27th	23	..	..
4.0	9.7	1.7	26.7	25.5	27.6	82	63	92	11.28	286.4	53.6	21st	21	..	...
4.2	5.6	1.0	28.0	30.0	28.4	82	77	95	23.61	599.7	121.2	25th	22	..	..
3.4	6.1	0.9	28.6	30.0	28.4	85	76	96	15.61	396.6	69.2	28th	21	..	.
4.1	8.8	2.0	27.0	26.0	26.4	82	65	90	15.26	387.6	100 9	25th	21	..	.
4.2	7.8	1.8	27.0	26.5	28.5	81	69	91	7.19	182.5	82.0	29th	16	..	..
4.5	7.0	1.4	27.1	27.2	27.0	80	71	93	13.78	350.0	88.6	28th	25	..	..
5.5	6.7	1.5	27.1	27.9	28.7	77	73	93	9.48	240.8	59.9	5th	15	..	..
3.1	5.8	0.8	27.2	30.4	29.8	87	77	96	9.65	245.1	42.7	23th	15	..	..
2.9	6.6	1.6	29.2	28.9	27.8	87	74	93	22.90	581.6	77.0	23rd	22	..	..
3.5	9.7	1.4	26.7	26.2	26.8	84	63	93	11.57	294.0	53.0	29th	24	..	..
4.0	8.1	1.4	27.0	26.9	26.2	82	68	93	6.42	163.1	82.0	25th	18	..	..
2.5	6.9	1.6	27.1	27.0	26.9	88	71	92	10.39	264.0	51.4	15th	22	..	..
2.5	7.6	1.0	25.4	25.9	28.8	88	69	95	12.38	313.1	78.0	22nd	20	..	..
2 6	4.9	1.6	26.6	25.6	23.4	88	78	92	15.24	387.0	106.0	28th	18	..	..
4.9	9.0	1.7	26.3	25.8	27.1	78	65	92	16.91	429.4	133.8	28th	19	...	..
4.3	7.4	0.7	27.7	27.4	28.8	81	70	97	9.81	249.2	45.0	29th	12	..	..
3.6	7.5	1.6	27.5	27.0	27.5	84	70	92	6.90	175.3	25.5	28th	22	4.88	144.80
4.2	8.3	1.6	27.0	26.3	28.4	81	67	93	8.13	206.5	35.0	28th	20	..	..
3.7	6.5	2.3	28.1	28.9	27.0	83	74	89	5.97	151.7	36.0	23rd	15	6.24	187.30
5.1	5.7	1.3	27.7	29.4	28.8	79	77	92	9.78	248.4	56.1	23rd	17	..	..
4.6	8.7	3.7	27.0	25.5	25.4	80	66	83	5.68	144.3	33.5	19th	18	..	..
4.8	7.8	2.1	27.0	25.8	26.9	79	68	90	15.19	285.8	65.8	28th	17	..	..
4.0	7.9	1.1	27.3	25.7	27.8	82	68	95	8.46	214.9	40.4	28th	14	..	..
..	..	..	..	..	..	..	..	..	8.53	216.7	33.5	29th	19	..	..
3.2	7.1	1.2	29.5	27.6	28.7	86	72	94	16.72	424.7	84.1	17th	25	..	..
..	..	..	..	..	..	..	..	.	3.95	100.3	35 6	28th	12	..	..
4.1	7.6	3.3	29.1	27.1	26.6	88	70	85	4.94	125.5	24.9	6th	12	..	..
3.0	4.2	1.4	30.1	31.3	30.2	87	82	93	11.38	289.1	76.2	15th	17	..	...
4.3	10.1	1.3	26.7	24.8	26.7	81	62	94	4.78	121.4	25.9	26th	15	..	..
2.0	13.1	2.1	28.3	24.1	26.9	91	58	90	15.87	403.1	94.0	29th	16	..	..
3.2	7.5	1.4	26.9	26.9	27.2	85	70	93	8.38	211.6	44.2	28th	15	..	..
3.6	9.6	1.6	27.2	26.1	27.6	84	64	92	8.40	213.4	35.8	28th	15	..	..
4.6	5.9	1.5	28.7	28.7	27.5	81	75	92	8.42	213.9	74.9	29th	10	..	..
5.3	7.1	2.5	27.3	27.6	27.8	78	72	88	12.18	309.4	91.5	29th	13	..	..
3.5	10.2	1.7	27.4	25.0	27.1	84	62	92	4.77	121.2	34.1	25th	13	5.93	178.00
2.2	3.3	0.8	18.2	18.7	17.7	88	84	95	13.31	333.0	49.0	27th	27	3.39	101.55
1.5	2.2	..	17.9	18.7	..	92	89	..	14.10	358.1	56.2	27th	27	3.46	108.95
2.5	3.5	1.3	19.2	20.1	18.8	87	88	93	7.86	199.7	49.3	16th	16	4.80	143.95
3.3	2.4	3.2	19.6	21.5	18.4	84	88	84	20.48	520.2	97.4	20th	23	..	..

...or.	Most in a day.	Date.	No. of rainfall days.
m.	m.m.		
2.2	70.9	13th	9
3.0	25.0	23rd	22
3.5	23.7	28th	14
1.5	54.4	15th	17
5.3	46.7	15th	14

Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mantin ..	6.13	155.7	27.7	17th	17

Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mentakab ..	7.36	186.9	36.8	16th	12
S. Lembing.	9 26	235.2	77.7	29th	20
Rompin ..	4'42	112.3	19.3	10th	11

L SERVICE.

RVATIONS, OCTOBER, 1929.

Humidity. Means. Depression of Wet Bulb. 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure. 9 A.M.	3 P.M.	9 P.M.	Percentage. 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
5.6	8.8	2.0	26.9	26.8	28.0	77	67	91	7.38	187.5	81.5	30th	18	..	..
4.1	9.3	1.4	26.6	25.6	28.3	82	64	93	6.94	176.2	58.5	22nd	17	..	..
5.4	9.4	1.9	26.3	25.4	27.6	76	68	91	10.13	257.2	75.0	22nd	21	..	..
5.1	6.7	1.1	27.6	29.1	28.7	79	73	95	11.33	287.8	119.8	26th	17	..	..
4.1	7.0	1.2	28.4	29.4	28.9	83	72	94	5.37	136.3	41.9	26th	17	..	..
4.9	10.1	2.0	26.3	25.3	27.0	73	62	90	13.48	342.4	49.5	25th	14	..	..
4.7	8.1	1.7	27.3	26.8	28.7	79	68	92	11.39	289.3	55.0	30th	14	..	..
5.1	8.6	1.1	26.9	26.9	27.7	78	67	95	13.78	350.0	63.0	21st	19	..	..
6.2	7.5	1.8	27.1	27.0	28.1	74	70	92	5.42	137.7	88.0	28th	11	..	..
3.5	[illegible]	1.9	29.7	29.5	28.8	85	76	91	7.48	190.0	37.9	3rd	16	..	..
4.4	[illegible]	1.8	28.3	29.0	28.3	81	70	92	9.50	241.2	67.6	22nd	17	..	..
4.0	9.9	1.9	27.0	27.1	27.2	82	63	91	2.24	57.0	15.0	6th	12	..	.
5.0	8.8	1.6	27.0	26.9	25.2	78	66	92	11.73	297.9	67.3	3rd	18	..	...
3.1	7.9	1.9	26.6	26.6	26.4	86	68	91	5.21	132.4	49.4	22nd	18	..	..
3.3	6.8	1.5	25.3	24.6	23.3	85	71	92	4.07	103.5	12.7	4th	18	..	..
2.6	5.8	1.5	26.5	25.5	24.1	88	77	92	7.93	201.5	55.0	20th	16	..	..
6.1	10.5	2.0	25.6	25.6	27.8	74	61	91	6.30	160.0	46.6	18th	18	..	...
4.9	7.8	0.6	27.9	27.3	28.9	79	69	97	5.02	127.4	26.2	4th	12	..	..
4.2	6.3	1.3	27.7	27.5	27.8	81	74	94	12.21	310.1	73.4	22nd	19	5.00	155.00
5.0	7.1	1.5	26.6	27.0	28.5	78	71	93	11.17	283.7	58.9	22nd	17	.	..
4.7	5.5	2.1	27.6	29.0	27.1	80	77	80	10.29	261.4	52.6	12th	15	6.22	192.85
5.4	6.5	1.4	27.7	27.4	28.0	77	73	93	5.78	146.8	22.3	27th	20	...	..
5.3	7.7	3.3	26.8	26.4	24.8	77	69	85	8.80	223.5	36.3	27th	17	..	..
5.1	6.7	1.4	26.3	26.8	27.7	78	72	93	12.11	307.6	48.5	21st	16	..	..
4.8	7.4	0.8	26.6	26.6	27.7	79	70	96	23.64	600.5	149.6	31st	22	..	..
..	..	..	..	..	..	..	..	..	18.45	341.6	37.3	23rd	21	..	..
4.8	8.0	1.1	28.5	27.3	29.3	80	68	95	8.83	224.3	34.3	26th	28		.
..	..	..	..	..	..	..	..	..	7.04	178.8	63.5	30th	19	..	..
6.1	7.6	1.4	26.4	27.0	27.3	75	70	93	5.30	134.6	48.2	22nd	13	..	..
3.4	4.3	1.2	29.9	32.1	30.6	85	82	94	14.92	379.2	109.2	31st	11	..	..
3.9	11.1	1.3	27.1	23.7	26.8	82	58	94	6.67	169.4	25.4	31st	19	..	..
2.7	12.9	2.1	27.8	24.7	27.4	87	54	90	5.29	134.4	24.4	17th	17		
3.9	9.3	1.3	26.4	25.0	26.8	82	68	94	12.87	326.9	137.2	22nd	14	..	..
4.0	9.1	1.2	26.9	26.2	27.5	82	65	94	8.19	208.0	39.4	24th	17	..	..
4.5	6.9	1.4	28.2	27.7	27.4	81	72	93	12.48	317.0	72.1	28th	14	..	..
4.5	7.4	2.1	27.0	27.3	27.7	80	70	90	11.19	284.2	81.8	27th	18	..	..
3.1	9.3	1.2	27.1	25.4	27.2	86	64	94	10.89	276.6	50.6	2nd	20	5.89	182.60
2.6	3.8	1.1	17.0	18.0	17.8	82	81	94	4.93	125.2	26.9	22nd	20	4.19	129.85
2.7	2.9	..	17.0	17.8	...	86	85	..	5.34	135.7	37.3	22nd	21	4.29	132.95
2.6	4.1	1.9	18.7	19.3	18.0	87	81	90	10.23	259.8	73.9	22nd	24	4.71	145.85
3.0	2.1	1.8	20.0	22.0	20.4	85	90	91	11.01	279.7	41.0	21st	24	..	..

S.

r.	Most in a day.	Date.	No. of rainfall days.
m.	m.m.		
1.6	22.5	31st	8
3.2	54.1	13th	19
9.4	44.4	23rd	19
8.7	77.2	29th	14
5.2	67.3	23rd	18

Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mantin ..	12.50	317.5	63.5	3rd	19

Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
	Ins.	m.m.	m.m.		
Mentakab ..	7.36	186.9	83.8	3rd	17
S. Lembing ..	13.75	349.3	99.8	21st	21
Rompin ..	13.32	338.3	65.0	29th	16

RVATIONS, NOVEMBER, 1929.

Humidity. Means. Depression of Wet Bulb 9 A.M.	3 P.M.	9 P.M.	Vapour Pressure. 9 A.M.	3 P.M.	9 P.M.	Percentage 9 A.M.	3 P.M.	9 P.M.	Rainfall. Total.		Most in a day. Amount.	Date.	No. of rainfall days.	Bright Sunshine. Daily mean.	Total.
°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
4.6	4.2	1.6	27.7	28.1	28.5	80	82	93	26.91	683.5	126.5	8th	26	..	..
3.4	6.6	1.1	27.0	27.4	28.4	84	78	95	21.64	549.7	112.2	20th	20	..	..
3.3	6.8	1.1	27.0	26.9	27.9	88	72	95	20.45	519.4	187.0	26th	25	..	...
3.9	4.0	1.0	28.5	31.1	28.2	88	83	95	17.17	436.1	52.8	2nd	27	..	..
3.1	6.0	1.1	28.2	29.2	27.9	87	76	95	19.06	484.1	56.8	23rd	25	..	.
3.5	8.8	1.8	27.0	26.1	26.9	84	65	91	21.21	538.7	63 8	25th	22	..	.
3.0	6.2	1.4	28.8	28.1	28.7	86	74	93	15.77	400.5	100.5	7th	19	..	..
4.5	6.6	1.1	27.2	27.6	37.7	80	78	95	29.67	753.6	96.5	3rd	24	..	..
5.6	5.7	1.0	27.8	27.9	28.6	77	76	95	12.70	322.6	68.1	6th	18	..	..
2.9	5.7	1.9	29.7	29.2	27.6	87	77	91	14.42	366.3	58.1	3rd	21	..	..
3.6	6.7	1.6	28.7	29.2	27.9	85	73	93	14,61	371.0	58.4	26th	23	..	..
3.6	8.9	1.8	27.2	26.7	26.5	84	65	91	14.61	371.0	52.0	28th	20	..	..
3.7	5.5	1.3	27.2	28.1	26.8	83	77	94	21.25	539.8	85.3	19th	28	..	..
3.1	7.4	1.2	26.6	26.0	27.3	86	69	94	9 04	229.7	24.4	24th	24	..	..
3.4	4.4	1.2	25.3	25.5	23.2	84	80	94	8.92	226.6	45.6	24th	18	..	..
3.2	4.6	1.6	26.4	26.1	23.9	85	80	92	11.14	283.0	62.5	1st	15	..	..
3.6	10.3	2.2	29.5	26.1	28.2	85	61	90	10.72	272.4	49.0	2nd	22	...	..
3.3	5.8	0.5	28.7	28.8	28.9	86	76	98	8.22	208.9	34.0	21st	23	..	..
3.3	6.3	1.1	28.6	27.8	28.2	85	74	95	18.73	475.7	102.6	28th	24	4.85	145.85
3.9	6.9	1.8	27.5	27.0	28.3	82	71	94	14.76	374.9	62.0	28th	23	..	..
3.4	5.8	1.1	28.7	28.9	27.8	85	76	95	9.93	252.2	45.5	20th	22	6.43	192.90
4.9	6.6	0.9	28.0	28.0	28.5	79	75	96	11.01	279.7	77.2	19th	22	..	..
4.1	6.7	2.5	27.9	26.5	24.0	82	72	88	15.05	382.3	97.8	21st	22	..	..
4.3	5.2	1.5	27.3	27.6	27.0	81	78	93	18.23	463.0	66.1	18th	23	..	..
4.6	5.4	0.7	27.0	27.6	27.8	80	77	97	16.62	422.2	96.0	21st	23	..	..
..	..	..	..	..	..	..	..	..	8.70	221.0	41.2	14th	20	..	..
3.9	7.6	0.9	29.2	27.4	29.6	88	70	96	18.28	464.3	104 8	7th	28	..	..
..	..	..	..	..	.	..	..	..	10.70	271.8	57.7	18th	17	..	..
5.6	6.2	1.4	26.1	28.5	27.7	76	75	93	12.98	329.7	40.7	6th	22	..	..
3.0	4.8	1.4	29.8	30.1	29.2	87	80	93	15.78	400.8	82.6	15th	15	.	...
3.8	8.0	1.4	27.0	26.1	26.3	83	68	93	15.80	401.3	58.6	5th	24	..	..
2.5	11.3	1.9	27.2	25.7	27.5	88	58	91	13.38	339.9	55.4	21st	21	..	..
3.0	6.5	1.0	27.0	26.7	27.8	86	73	95	12.63	320.8	71.1	23rd	23	..	..
3.7	7.4	0.8	27.0	27.2	28.2	83	70	96	10.29	261.4	81.3	19th	28	..	..
3.4	4.9	1.1	28.6	28.3	27.9	85	79	95	15.92	404.4	66.1	1st	16	..	..
3.9	5.5	2.0	27.3	27.6	27.4	82	77	90	13.06	331.7	79.3	17th	13	..	..
2.6	7.1	1.1	27.6	27.2	27.9	88	71	95	6.27	159.3	22.9	14th	23	4.83	145.00
3.1	2.6	0.7	18.7	19.4	18.0	85	87	96	14.45	367.1	65.0	17th	26	3.17	94.95
2.4	1.5	..	18.0	19.4	..	87	92	..	12.72	323.1	44.5	17th	26	3.28	98.50
1.7	2.4	1.0	19.1	20.1	18.8	91	88	95	16.65	422.9	51.8	20th	27	4.13	124.00
3.0	1.5	1.9	20.8	21.9	19.7	85	93	90	25.20	640.0	70.8	28th	27	..	..

S.

...or	Most in a day.	Date.	No. of rainfall days.	Negri Sembilan. —	Total.		Most in a day.	Date.	No. of rainfall days.	Pahang. —	Total.		Most in a day.	Date.	No. of rainfall days.
m.m.	m.m.				Ins.	m.m.	m.m.				Ins.	m.m.	m.m.		
91 8	42.9	6th	18	Mantin ..	15.55	395.0	81.	19th	22	Mentakab ..	6.88	174.8	34.5	23rd	14
87.9	50.8	28th	21							S. Lembing.	17 49	444.8	104.9	20th	26
84.8	86.2	19th	21							Rompin ..	12.48	315.7	58.7	19th	24
84.5	48.2	15th	18												
07.9	58 7	14th	20												

SERVICE.

RVATIONS, DECEMBER, 1929.

Humidity.									Rainfall.					Bright Sunshine.	
Means.															
Depression of Wet Bulb.			Vapour Pressure.			Percentage.			Total.		Most in a day.		No. of rainfall days.	Daily mean.	Total.
9 A.M.	3 P.M.	9 P.M.	9 A.M.	3 P.M.	9 P.M.	9 A.M.	3 P.M.	9 P.M.			Amount.	Date.			
°F	°F	°F	m.b.	m.b.	m.b.	%	%	%	Ins.	m.m.	m.m.			Hrs.	Hrs.
5.5	9.2	1.8	26.6	26.0	28.7	77	65	92	11.08	281.5	80.0	15th	14	..	..
4.9	11.4	2.4	24.6	24.0	27.8	78	37	89	1.60	40.7	20.0	26th	8	..	..
5.4	11.4	2.1	25.2	24.7	27.6	76	57	90	5.60	142.2	59.0	5th	8	..	..
4.7	8.0	1.0	27.5	28.9	29.7	79	69	95	3.82	97.0	29.5	15th	14	..	..
4.8	9.2	1.5	26.5	28.8	28.8	79	65	98	6.19	157.1	46.1	7th	11	..	..
4.4	10.6	2.0	26.8	25.8	27.6	80	60	91	5.76	146.3	45.7	15th	8	..	..
3.8	6.0	1.5	27.6	29.0	28.1	85	76	98	9.39	238.5	70.0	6th	9	..	..
5.1	9.5	1.6	26.9	26.7	27.8	78	64	98	4.66	118.4	88.0	25th	12	..	..
6.0	9.5	1.1	26.6	26.0	28.7	75	68	95	5.65	148.5	85.6	18th	9	..	..
3.9	8.7	1.7	28.2	27.6	28.7	82	67	92	3.20	81.3	19.8	4th	8	..	..
4.0	9.9	2.0	27.4	28.6	28.8	82	68	91	3.33	84.6	40.0	14th	8	..	..
5.1	11.2	2.2	25.0	25.4	27.0	78	59	89	1.42	36.0	11.0	16th	5	..	..
3.9	9.1	1.5	27.7	27.4	26.8	82	66	98	3.75	95.3	44.2	28th	12	..	...
4.6	11.9	1.0	28.5	22.7	28.0	79	55	95	1.02	25.9	17.3	18th	6	..	..
3.6	8.9	1.2	24.5	24.5	24.2	84	64	94	4.86	123.4	65.0	3rd	5	..	..
2.9	9.3	0.7	26.0	28.3	25.2	86	68	96	0.98	25.0	25.0	15th	1	..	..
3.0	11.7	2.1	31.8	25.8	28.9	87	58	91	4.08	103.6	25.6	18th	10	..	...
4.7	7.6	0.6	27.6	27.6	29.3	78	70	97	2.48	63.0	14.0	18th	10	..	..
5.1	9.0	2.2	26.0	25.4	26.3	78	65	89	5.37	136.4	65.5	20th	13	6.78	208.50
5 5	10.0	2.2	26.1	25.2	27.8	76	62	90	4.61	117.1	38.1	12th	12	..	..
4.6	6.7	1.4	27.6	29.1	28.0	80	73	93	4.86	123.5	21.1	27th	13	8.00	248.10
5.8	10.4	1.4	26.7	27.4	28.1	76	61	98	2.47	62.7	22.9	20th	7	...	..
4.9	7.2	2.2	27.4	27.2	24.2	78	71	89	8.74	222.0	93.7	19th	12	..	..
4 4	8.3	1.4	27.2	26.4	28.2	80	67	98	6.46	164.1	48.8	15th	15	..	..
6.8	9.8	0.9	25.2	25.1	27.9	78	63	96	4.81	122.2	81.5	31st	12	..	..
..	..	..	..	..	..	..	..	..	6.32	160.5	59.5	4th	19	..	..
5 4	8.1	1.1	27.4	27.2	29.4	77	68	95	7.27	184.6	82.6	17th	18	..	..
.	..	..	..	..	..	..	..	..	4.61	117.1	26.2	11th	16	..	..
6 1	7.3	1.7	26.9	27.0	27.1	75	70	92	3.17	80.5	19.8	27th	6	..	..
5.8	6.6	1.8	27.0	28.7	29.1	76	74	92	3.28	82.1	21.3	19th	9	..	..
3.9	9.6	1.2	27.0	25.1	26.5	82	64	94	3.28	83.3	17.3	24th	15	..	..
3.2	11.8	1.9	26.5	25.3	27.8	85	57	91	4.54	115.3	22.9	2nd	17	..	..
3.7	8.3	1.4	25.6	25.0	26.7	88	67	98	1.07	27.2	12.7	30th	6	..	..
3.8	9.9	1.1	26.6	25.8	27.8	85	62	95	9.38	238.3	37.1	4th	22	..	..
3.8	5.9	1.7	27.9	26.9	27.6	83	75	92	7.11	180.6	53.9	2nd	11	..	..
4.9	7.1	2.5	25.8	25.7	26.9	78	71	88	7.79	197.9	47.8	31st	12	..	..
3.1	9.7	1.6	26.9	24.8	27.1	86	62	92	3.89	98.8	56.4	10th	16	6.34	196.6
2.8	4.2	0.8	17.2	18.0	16.7	88	79	98	6.65	168.9	92.5	12th	19	5.17	160.20
3.8	5.2	..	16.7	18.0	..	88	84	..	5.30	134.6	56.9	12th	20	5.21	161.40
1.8	2.2	0.9	18.4	20.1	18.8	93	89	95	5.58	140.5	84.8	31st	19	3.74	116.15
4.2	2.5	2.1	19.2	21.8	19.7	80	88	89	6.02	153.0	40.0	2th	12	..	..

r.				Negri Sembilan.						Pahang.						
	Most in a day.	Date.	No. of rainfall days.	—	Total.		Most in a day.	Date.	No. of rainfall days.	—	Total.		Most in a day.	Date.	No. of rainfall days.
m.	m.m.				Ins.	m.m.	m.m.				Ins.	m.m.	m.m.		
9.9	80.6	1. 8	9	Mantin ..	2.28	56.7	17.0	20th	8	Mentakab ..	3.84	97 5	83.0	31st	9
4.8	84.1	12 h	12							S. Lembing ..	9.24	234.7	88.8	4th	20
6.0	15.4	19th	11							Rompin ..	7.08	179.8	81.8	5th	16
4.2	67.8	18th	10												
9 6	87.8	28th	14												

VOLUME XVII

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